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ODONTOLOGICAL SOCIETY

OF

GREAT BRITAIN.

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1863.——SAMUEL CARTWRIGHT, Jun., F.R.C.S.Eng. & L.D.S., &c.

LIST OF MEMBERS

OF THE

ODONTOLOGICAL SOCIETY OF GREAT BRITAIN.

1863.

EXPLANATIONS OF ABBREVIATIONS.

P.....President.
V.P...Vice-President.
T.....Treasurer.
L.....Librarian.
C.....Council.
H.F.S...Hon. Foreign Secretary.
H.S...Honorary Secretary.

Members are requested to forward to the Hon. Secretaries of the Society any alterations required in Addresses, &c.

	Elected.	
America	1859	ARTHUR, ROBERT, D.D.S., &c. Philadelphia. (*Corresponding.*)
	1859	BALLARD, CHARLES WILEY, M.D., &c. 139, Fourth Avenue, New York City. (*Corresponding.*)
	1859	BOND, THOMAS E., M.D., &c. (*Corresponding.*)
	1861	DUNNING, ——, M.D., &c. New York. (*Corresponding.*)
	1859	HARWOOD, DANIEL, M.D., &c. Boston. (*Corresponding.*)
	1859	McQUILLEN, JOHN HUGH, M.D., D.D.S., &c. 827, Arch Street, Philadelphia. (*Corresponding.*)
	1859	PARMLY, ELEAZAR, M.D., D.D.S., &c. 3, Bond Street, New York. (*Corresponding.*)
	1859	PIGGOTT, A. SNOWDEN, M.D. Baltimore. (*Corresponding.*)

	Elected.	
America	1859	TUCKER, JOSHUA. Boston. (*Corresponding.*)
	1859	WHITE, JOHN D., M.D., &c. 1115, Walnut Street, Philadelphia, Pennsylvania. (*Corresponding.*)
Amsterdam.....	1857	DENTZ, SIMON NATHANS, Jun. 545, Kloreniers Burgwal. (*Honorary.*)
Antigua	1863	COX, N. West Indies.
Australia	1860	BELLISARIO, JOHN, D.D.S. 147, Philip Street, Sydney (*Corresponding.*)
	1863	GURNER, J. R. North Terrace, Adelaide.
	1860	JORDAN, HENRY. Queensland. (*Corresponding.*)
	1858	NORMAN, ROBERT. Adelaide. (*Corresponding.*)
	1860	PATERSON, HUGH. 18, Elizabeth Street, North Sydney. (*Corresponding.*)
	1863	SKARDON, J. Melbourne.
Barnsley	1863	CARTER, E. Yorkshire.
Bath	1856	PARKINSON, G., Sen. (*Honorary.*)
	1856	PARKINSON, GEORGE THOMAS, L.D.S. 3, Princes Buildings. (C. 1861-62-63.)
Birmingham ...	1856	ENGLISH, T. R. M. Colmore Row. (C. 1860-61.)
	1860	HOWKINS, THOMAS, M.R.C.S.Eng. 37, Bennett's Hill.
	1861	PARKER, SAMUEL A., L.D.S. 18, Colmore Row.
	1856	ROBERTSON, W. The Square. (V.P. 1857-58.)
Blackburn	1860	PILLING, ROBERT CAMPBELL, L.D.S. 66, King William Street.
Bolton-le-Moors ...	1863	PATRICK, R. Silverwell House.
Boulogne-sur-mer...	1860	KEENE, JAMES J., L.D.S., 14, Grande Rue. (*Corresponding.*)

	Elected.	
Bradford	1863	SUTCLIFFE, James, L.D.S. 57, Drewton Street, North Parade.
Brighton	1857	EDEN, THOMAS EDWARD, M.R.C.S.Eng. 26, Old Steine.
	1862	FOX, O. A., L.D.S. 12, Pavilion Parade.
	1856	PARKINSON, EDWARD P., L.D.S. 10, Old Steine.
	1863	WALKER, G., L.D.S. 62, Ship Street.
	1863	WOOD, W. R. Carlisle House, Pavilion Buildings.
	1863	WOOD, W. R., Jun. Carlisle House, Pavilion Buildings.
	1863	WOOD, J. Carlisle House, Pavilion Buildings.
Bristol	1863	HAYMAN, S. A. 4, Cumberland Street.
	1863	LITTLE, S. 4, Cumberland Street.
	1863	PARSON, T. C. 16, Orchard Street.
	1861	PEARCE, WILLIAM. 9, Unity Street, College Green.
	1863	SMART, J. S. 44, Park Street.
Brussels.....	1859	TALMA, AMEDEE JULES LOUIS, M.D., &c. 8, Rue du Musée. (*Corresponding.*)
Bury St. Edmund's.....	1863	WAYLING, J. Angel Hill.
Carshalton ...	1859	RANDALL, E. B., L.D.S.
Cheltenham ...	1856	PALMER, THOMAS G., L.D.S. 1, Royal Crescent. (C. 1858-59, V.P. 1860-61-62.)
	1863	ROGERS, R. 58, Regent Street.
	1863	TIBBS, S. 58, Regent Street. (V. P. 1863.)
	1863	TIBBS, P. W. 58, Regent Street.
Chichester ...	1863	BRADLEY, W. T. 67, East Street.

	Elected.	
Clifton, Bristol	1857	WILLIAMS, G. S., L.D.S. 3, Chesterfield Place.
Colchester ...	1863	TWEED, R. St. John's Street.
Corfu	1863	VERSALOVICH, M. Ionian Islands.
Cork	1856	BARRY, RICHARD. 3, Camden Place.
Croydon	1863	CARPENTER, Dr. (*Honorary.*)
	1863	RYMER, S. L., L.D.S. 60, North End. (C. 1863.)
	1863	STEELE, J., L.D.S. 63, High Street.
Darlington ...	1863	FOTHERGILL, A. North Gate.
	1863	FOTHERGILL, W.
Derby	1857	MORLEY, HENRY. 9, London Road.
Dewsbury	1863	MARGETSON, W., L.D.S. Roseve Place.
Doncaster	1863	WALKER, F. D. 26, Hall Gate.
Dorking	1863	DURANT, F. High Street.
Dover	1863	ASH, G. 26, Castle Street.
	1857	LINDSEY, JOHN BURKE, L.D.S. 36, Castle Street.
Dublin	1859	BAKER, JOHN A., Licentiate and F.R.C.S.Ire. by Exm. 4, Clare Street, Merrion Square.
	1861	CORBETT, DANIEL, L.D.S. 12, Clare Street.
	1863	MACKINTOSH, W. 117, Stephen's Green.
	1859	MOORE, ROBERT H., F.R.C.S.Ire. 28, Upper Merrion Street. (C. 1861-62.)
	1857	RYDING, W. J., L.D.S. 11, Dawson Street.
Dundee	1862	CAMPBELL, WALTER, L.D.S. Tay Square.
Durham	1859	CALDCLEUGH, JOHN. 62, Old Elvet.

	Elected.	
Edinburgh	1859	CHISHOLM, JOHN KNOX, L.D.S. Duke Street
	1862	GOODSIR, PROFESSOR. (*Honorary.*)
	1859	HEPBURN, DAVID, L.D.S. 7, Abercrombie Place. (C. 1863.)
	1857	NASMYTH, ROBERT, F.R.S.Edin., F.R.C.S. Edin. 5, Charlotte Square. (V.P. 1857-58-59.)
	1859	ORPHOOT, PETER, M.D.Edin. 113, George Street.
	1859	ROBERTS, W. A., M.D.Edin., L.D.S., V.P.R.S.A. Edin., M.M.C.S.Edin. 30, Queen Street.
Egypt	1859	FINNIE, JOHN. Alexandria. (*Corresponding.*)
Exeter	1858	BRAND, EDWARD E. Cathedral Yard.
	1863	KING, N. 7, Bedford Circus.
	1856	SHEFFIELD, THOMAS. Palace Gate. (C. 1858.)
Florence	1857	DUNN, CHARLES W., L.D.S. 4245, Piazza Santa Maria Novella. (*Honorary.*)
Glasgow	1856	BUCHANAN, G. 1, Montague Place, Bath Street.
	1863	HORNE, J. 121, Douglas Street, Blythewood Square.
	1857	THOMPSON, F. H. 10, Brandon Place.
	1863	WISHART, J. 47, Bath Street.
	1863	WOODBURN, W. D. 8, South Portland Street.
	1863	WOODBURN, W. S. 8, South Portland Street.
	1863	YOUNG, J. A. 47, Bath Street.
	1863	YOUNG, J. H. 34, Dundas Street.
Gloucester ...	1863	FOWLER, C. J. High Street.
	1857	FOX, GEORGE F., L.D.S. Sussex House, Clarence Street.

	Elected.	
Guernsey	1858	HUGO, SAMUEL GEORGE JOSEPH. 15, Allez Street, New Town.
Hereford	1857	McADAM, GEORGE W. King Street.
Huddersfield .	1863	SHOLEFIELD, J. 6, South Street.
Huntingdon ...	1862	KIRBY, S. AMOS, L.D.S.
India	1863	LLOYD, F. R. Agra.
	1863	SHORTT, J., L.D.S. Chingleput.
Inverness	1863	GRANT, W. 20, Church Street.
Isle of Man ...	1863	GARRETT, P. L. 56, Athol Street.
	1863	KARRAN, J. 1, Edward Terrace, Douglass.
Isle of Wight .	1863	ALABONE, A. High Street, Newport.
	1863	HARRINGTON, G. F., L.D.S. Ednor House, Ryde.
Jamaica	1860	CALORIE, JOSEPH.
Java.....	1863	PHILLIPS, E. A. Batavia.
Jersey.....	1858	HUGO, H. R. St. Helier's.
Leamington ...	1862	JEPSON, ALFRED. 108, Warwick Street.
Leeds	1863	ATKINSON, J. H., L.D.S. 14, East Parade.
	1858	BRAE, ANDREW EDMUND. Park Square.
	1863	WOODCOCK, C. 3, Park Square.
	1863	WOODCOCK, E.
	1863	WOODCOCK, H. J.
Leicester	1860	KEMP, CHARLES GODFREY, M.R.C.S.Eng. 37, Gallow-Tree Gate.
	1863	LLOYD, G. T. Bank Buildings.
Liverpool	1859	GILL, SETH, L.D.S. 134, Islington.

	Elected.	
Liverpool	1863	NEWMAN, H. 5, Slater Street.
	1863	NEWMAN, W. J. 27, Great George Street.
	1863	NEWMAN, A. 5, Slater Street.
	1863	RANSOM, D. W. 24, Pembroke Place.
	1863	ROSE, J. E. 64, Mount Pleasant.
	1858	SNAPE, JOSEPH, L.D.S. 75, Rodney Street.
	1861	STEWART, ROBERT EDWARD. 37, Rodney Street.
London	1858	ANDERSON, JAMES. 14, Margaret Street, Cavendish Square.
	1862	ARNOTT, J. M., F.R.S., &c. 2, New Burlington Street. (*Honorary.*)
	1858	ASH, GEORGE, L.D.S. 15, Gt. Marlborough St.
	1861	BALKWILL, F. H., L.D.S. Campanell Cottage, Canonbury, Islington.
	1856	BARRETT, HENRY JOHN, M.R.C.S.Eng., & L.D.S. 42, Finsbury Square. (C. 1856-57-58, C. 1860-61.)
	1859	BARTLETT, EDWARD B., L.D.S. 38, Connaught Square.
	1859	BARTLETT, GEORGE. 15, Caroline Street, Bedford Square.
	1859	BALLARD, W. R. 35, Manchester Square.
	1860	BELL, THOMAS, F.R.S., P.L.S., F.G.S., F.R.C.S.Eng., & L.D.S., F.R.M.C.S. The Wakes, Selborne, Hants. (*Honorary.*)
	1863	BELL, J. B., M.R.C.S. Eng. & L.D.S. 30, Margaret Street.
	1859	BENNETT, W. G., L.D.S. 17, George Street, Hanover Square.

	Elected.	
London	1863	BETTS, H. C. 30, Wimpole Street.
	1856	BIGG, W. M., L.D.S. 18, Stratford Place. (C. 1856-57, V.P. 1858-59-60. P. 1861.)
	1863	BRENNEIS, J. D., L.D.S. 22c, Cavendish Square.
	1861	BROADWAY, W. 23, Gilbert Street, Grosvenor Square.
	1863	BROCK, J., L.D.S. 13, Berners Street.
	1856	CANTON, ALFRED G., M.R.C.S.Eng., & L.D.S. 17, Great Marlborough Street. (C. 1856-57-58, H.S. 1859-60-61, H.F.S. 1862-63.)
	1863	CANTON, W. L. 18, Hanover Street.
	1856	CARTWRIGHT, SAMUEL, F.R.S. Nizell's House, Tonbridge, Kent. P. 1856-57. (*Hon.*)
	1856	CARTWRIGHT, SAMUEL, Jun., F.R.C.S.Eng., & L.D.S., &c. 32, Old Burlington Street. (H.S. 1856-57-58, H.F.S. 1859, V.P. 1860-61-62. P. 1863.)
	1856	CATTLIN, W. A. N., F.R.C.S.Eng., & L.D.S. 1, Highbury Place, Islington. (C. 1860-61-62, V.P. 1863.)
	1863	CHAPMAN, W. 35, Maddox Street.
	1863	COAR, F. 60, Wimpole Street.
	1860	COCKINGS, W. S. 20, University Street.
	1857	COLEMAN, ALFRED, M.R.C.S.Eng., & L.D.S., 3, Finsbury Square. (C. 1861, H.S. 1862-63.)
	1857	CRAMPTEN, W., L.D.S. 22, Grosvenor Street. (C. 1863.)
	1857	DAVIS, JAMES. 9, Old Cavendish Street.
	1861	DEVONSHIRE, J. K., L.D.S. 17, Tavistock Street, Bedford Square.

	Entered.	
London	1856	DREW, JOHN. 13, New Burlington Street. (C. 1861-62.)
	1857	DUFF, A. M. 18, Queen Anne Street, Cavendish Square.
	1860	ELLIOTT, J. W., M.R.C.S.Eng., L.D.S. 4, Finsbury Square.
	1863	FINZI, S. L. 20, York Place, City Road.
	1856	FLETCHER, JOHN B., L.D.S. 17, New Burlington Street. (C. 1859-60-61, L. 1862-63.)
	1856	FOX, CHARLES JAMES, L.D.S. 27, Mortimer Street, Cavendish Square. (C. 1863.)
	1860	FORSYTH, W. F., L.D.S. 63, Grosvenor Street.
	1863	FRANKLIN, G. P. 38, Westbourne Grove.
	1859	GHRIMES, S. 65, Gloucester Place, and Nice.
	1862	GIBBONS, S. C., L.D.S. 13, New Burlington St.
	1863	GIBBS, F. 20, Pentonville Road.
	1863	GILBERT, W. J. 4, Old Quebec Street.
	1862	GREEN, J. H., F.R.S., &c. Hadley, Barnet. (*Honorary.*)
	1857	GREGSON, G., L.D.S. 12, Harley Street.
	1859	HAMPSON, J. D. C., L.D.S. 7, Dorset Square.
	1863	HARDING, T. H., L.D.S. 19, Park Square, Regent's Park.
	1863	HARRIS, H. 5, Gower Street.
	1856	HARRISON, W. A., F.R.C.S.Eng., & L.D.S., L.S.A., &c. 10, Keppel Street, Russell Square. (V.P. 1857-58-59, P. 1860, C. 1862-63.)
	1863	HARRISON, R., L.D.S. 13, Camden Street North, Camden Terrace.

	Entered.	
London	1860	HART, ADOLPHUS D., M.R.C.S.Eng. & L.D.S., 61, Brook Street.
	1861	HAYWARD, HENRY H., M.R.C.S.Eng. & L.D.S., F.R.M.C.S. 56, Queen Anne Street, Cavendish Square.
	1856	HEATH, JOHN. 11, Albemarle Street. (C. 1860.)
	1863	HELFRICH, R., L.D.S. 25, Notting Hill Terrace.
	1863	HENRY, G. 22, Poultry, City.
	1859	HEPBURN, ROBERT, L.D.S., &c. &c. 8, Davies Street, Berkeley Square. (C. 1862.)
	1861	HILL, ALFRED, L.D.S. 38, Euston Square.
	1863	HOCKLEY, A. 45, Great Marlborough Street.
	1863	HULME, R. T., M.R.C.S.Eng. 25, Argyle Street. (C. 1863.)
	1862	HUXLEY, T. H., F.R.S., &c. 14, Waverley Place, St. John's Wood Road. (*Honorary.*)
	1856	IBBETSON, GEORGE A., F.R.C.S.Eng., & L.D.S., F.G.S., &c. 30, Cavendish Square. (C. 1857-58-59, H.S. 1860-61-62, C. 1863.)
	1863	IMRIE, W. 16, Savile Row. (V.P. 1863.)
	1858	JAMESON, WILLIAM EDWARD, L.D.S. 78, Grosvenor Street.
	1857	JONES, A. B., M.R.C.S. Eng., & L.D.S. 53, Brook Street, Grosvenor Square.
	1863	KEMPTON, H. T., L.D.S. 17, Cavendish Place (C. 1863.)
	1861	LAURIE, GEORGE, D.D.S., &c. 26, Mortimer Street, Cavendish Square.
	1862	LAURENCE, W., F.R.S., &c. 18, Whitehall Place. (*Honorary.*)

	Entered.	
London	1859	LITTLEWOOD, JOHN, L.D.S. 14, Lower Eaton Street.
	1860	LOWE, EDWIN, M.R.C.S.Eng. 6, George Street, Hanover Square.
	1856	LUXMORE, CORYNDON HENRY, F.A.S. 21, Keppel Street.
	1858	MANTON, JOHN N. 78, Grosvenor Street.
	1860	MAY, WILLIAM H. 26, Guildford Street, Russell Square.
	1856	MUMMERY, JOHN R., L.D.S., F.L.S. 10, Cavendish Place. (C. 1861-62-63.)
	1856	NAPIER, WILLIAM D., M.R.C.S.Eng. 22, George Street, Hanover Square.
	1863	NOLAN, W. H. 24, Charles Street. Middlesex Hospital.
	1856	NORMANSELL, FREDERICK, L.D.S. 1, Gloucester Street, Portman Square.
	1857	OSWIN, FREDERICK. 22, Upper Berkeley Street, Portman Square.
	1858	OWEN, GEORGE, L.D.S. 24, Compton Terrace, Islington.
	1861	OWEN, PROFESSOR R., F.R.S., &c. British Museum. (*Honorary.*)
	1860	PARKS, WILLIAM J. 7, Princes Street, Hanover Square.
	1856	PARKINSON, JOHN HERRING, L.D.S. 36, Sackville Street, Piccadilly. (V.P. 1856-57, P. 1858, C. 1862.)
	1856	PARKINSON, JOHN H., Jun., M.R.C.S.Eng. 36, Sackville Street, Piccadilly. (C. 1857-58-59.)

	Elected.	
London	1856	PARKINSON, JAMES, L.D.S. 1, King Street St. James's Square. (C. 1857-58-59, C. 1863.
	1860	PARKINSON, GEORGE, M.R.C.S.Eng., L.S.A 16, Hereford Street, Park Lane.
	1863	PERKINS, H. J., L.D.S. 379, City Road.
	1863	PERKINS, W., L.D.S. 175, Prospect Place Maida Hill. (V.P. 1863.)
	1863	PORTER, W. P. 15, Finsbury Place South.
	1859	PRATT, R. J. H. 202, Piccadilly.
	1863	RICHARDSON, Dr. 12, Hind Street, Mancheste Square. (*Honorary.*)
	1856	ROGERS, ARNOLD, F.R.C.S.Eng., & L.D.S. F.G.S.,&c. 16, Hanover Square. V.P.1857-58 P. 1859, T. 1861-62-63.)
	1856	ROGERS, THOMAS ARNOLD, M.R.C.S.Eng & L.D.S. 16, Hanover Square. (H.S. 1856-57 58-59, H.F.S. 1860-61, V.P. 1862-63.)
	1856	ROGERS, HENRY, M.R.C.S.Eng., & L.D.S 16, Hanover Square.
	1859	ROGERS, JOSEPH, M.R.C.S.Eng., & L.D.S 16, Hanover Square.
	1856	ROGERS, CHARLES, L.D.S. 2, Cork Street Burlington Gardens. (C. 1862.)
	1861	ROGERS, FREDERICK W., L.D.S. 5, Sackville Street, Piccadilly.
	1863	ROSS, G., L.D.S. 16, South Street, Finsbury Square.
	1863	RUNTING, W. 68, South Audley Street.
	1860	SALTER, S. J. A., M.B., M.R.C.S.Eng., & L.D.S. 17, New Broad Street.

	Entered.	
London	1856	SAUNDERS, EDWIN, F.R.C.S.Eng., &c. &c. 13A, George Street, Hanover Square. (T. 1856-57-58-59-60, V.P. 1861-62-63.)
	1856	SAUNDERS, JOSIAH, L.D.S. 42, Albemarle Street.
	1857	SAUNDER, W. D., L.D.S. 11, Lower Seymour Street, Portman Square. (C. 1862-63.)
	1857	SCOTT, WILLIAM HENRY, L.D.S. 23, Wimpole Street.
	1856	SERCOMBE, EDWIN, M.R.C.S.Eng., & L.D.S., F.R.M.C.S. 49, Brook Street. (C. 1859-60-61.)
	1862	SHARPEY, W., M.D., F.R.S. 33, Woburn Place. (*Honorary.*)
	1856	SHEFFIELD, ISAAC. 2, Stratford Place. (C. 1861-62-63.)
	1863	SMALE, H. 19, Great Marlborough Street.
	1863	SMITH, H., L.D.S. 61, Oakley Square, Hampstead Road.
	1863	SMITH, J. A., L.D.S. 47, Smith Street, Chelsea.
	1863	SPENCER, H. L. 18, Orchard Street.
	1858	STEVENSON, NATHANIEL, M.R.C.S.Eng & L.D.S. 62, Cleveland Square. (C.1863.)
	1863	STODDART, C. 43, Connaught Terrace.
	1859	STOKES, CHARLES, M.R.C.S.Eng. 65, Brook Street, Hanover Square.
	1863	THOMSON, R., L.D.S. Elm House, Denmark Hill.
	1856	TOMES, JOHN, F.R.S., M.R.C.S.Eng., & L.D.S., &c. &c. 37, Cavendish Square. (H.S. 1856-57-58, V.P. 1859-60-61, P. 1862.)

	Entered.	
London	1856	TRACY, SAMUEL JOHN, L.R.C.P. Edin. (Exam.), M.R.C.S.Eng., F.R.M.C.S. 28, Old Burlington Street.
	1862	TREVELYAN, Sir C., K.C.B. 5, Grosvenor Crescent. (*Honorary.*)
	1861	TRUMAN, EDWIN, M.R.C.S.Eng., F.R.M.C.S., &c. 23, Old Burlington Street.
	1859	UNDERWOOD, THOMAS, L.D.S., &c. 7, Gower Street, Bedford Square. (C. 1860-61-62.)
	1863	USHER, C. F. 16, Gracechurch Street.
	1856	VASEY, CHARLES, L.F.P.S. & L.D.S. 5, Cavendish Place, (C. 1862, H.S. 1863.)
	1863	VIDLER, T. C. 22, Eastbourne Terrace.
	1863	WAITE, G. 2, Old Burlington Street.
	1857	WALKINGSHAW, BURNLEY, L.D.S. 8, Princes Street, Cavendish Square.
	1860	WALKER, JOSEPH, M.R.C.S.Eng., & L.D.S. 82, Wimpole Street.
	1863	WEAVER, G., L.D.S. 41, Upper Baker Street.
	1863	WEISS, F. 32, Great Russell Street.
	1857	WEST, BYATT. 69, Old Broad Street, City.
	1862	WEST, J. T. H., M.R.C.S.Eng. & L.D.S. 69, Old Broad Street, City.
	1863	WEST, C. 9, London Terrace, Hackney Road.
	1863	WILLIAMS, G., L.D.S. 17, Cavendish Place.
	1863	WINTERBOTTOM, E. J., L.D.S. 16, Sloane Street.
	1863	WINTERBOTTOM, E. J., Jun., M.R.C.S. & L.D.S. 16, Sloane Street.

	Entered.	
London	1856	WOODHOUSE, ALFRED J., L.D.S. 1, Hanover Square.
	1859	WOOLFRYES, HENRY A., L.D.S. 1, Gloucester Street, Portman Square.
	1863	ZINKGRAFF F. 22c, Cavendish Square.
Madras	1862	CLARKE, SMOLLETT W.
	1862	PORTEUS, H. W., M.D. (*Honorary.*)
Maidstone	1863	SMITH, J. C. 8, Week Street.
Malvern.....	1863	WILLIAMS, E.
Manchester ...	1856	BROOKHOUSE, ROBERT, L.D.S. Mosely Street. (C. 1859-60, V.P. 1861-62-63.)
	1862	CAMPION, H., M.R.C.S.Eng. 305, Brighton Place, Oxford Street.
	1863	HOPKINSON, W. 30, Broughton Road, Salford.
	1863	KELLY, T. M. 13, Chatham Street, Piccadilly.
	1858	SMITH, GEORGE W., M.R.C.S.Eng. & L.D.S. 6, Aytoun Street.
	1860	ROGERS, SIMON ALFRED., L.D.S. 19, St. John's Street, Deansgate.
Newbury	1856	ROGERS, CHARLES DEEBLE, L. D. S. (C. 1863.)
Newcastle-on-Tyne ...	1863	NIGHTINGALE, D. J. 9, New Bridge Street.
New Zealand...	1857	COOK, AUGUSTUS. Princes Street, Auckland.
Norwich	1863	BOULGER, J. P. St. Giles's Street.
	1857	BRIDGMAN, W. K., L.D.S. 69, St. Giles's Street. (C. 1861-62, V.P. 1863.)
	1856	WHITE, RICHARD, L.D.S. St. Giles's Street. (C. 1862-63.)

	Entered.	
Northampton...	1863	WILKINS, B. St. Giles's Square.
Nottingham ...	1863	BELLAMY, G. W. 17, Derby Road.
	1863	BOWMER G. High Pavement.
	1859	HEPBURN, DUNCAN DEWAR, L. D. S. Regent Street. (C. 1862-63.)
	1857	ORROCK, JAMES, M.R.C.S. Edin., L.D.S. Regent Street.
Oxford	1862	VIRGIN, H. J. 63, High Street.
Paisley	1863	CAMERON, T. R. 18, St. James's Street.
	1863	DOBIE, J. 92, High Street.
Paris	1859	EVANS, THOMAS WILLIAM. 15, Rue de la Paix. (*Corresponding.*)
	1861	BYGRAVE, CHARLES. 3, Rue Laffitte.
Penzance	1860	MAGOR, MARTIN, L.D.S. 24, Chapel Street.
Perth	1860	BELL, JAMES, L.D.S. 2, Charlotte Street.
Peterboro'.....	1859	PALMER, JAMES EDWIN. Priestgate.
Plymouth	1856	BATE, CHARLES SPENCE, F.R.S., L.D.S. 8, Mulgrave Place. (C. 1859, V.P. 1862-63.)
	1857	COLES, JAMES STRATTON. 3, Princes Square.
	1857	JEWERS, FREDERICK ARTHUR. 4, Flora Place, Union Road.
	1862	MOORE, W. V., L.D.S. 15, Princes Square.
	1860	TUBBS, C. F. 4, Athenæum Terrace.
Portsmouth ...	1856	MARTIN, JOHN, F.L.S., L.D.S. Cambridge House (C. 1858, V.P. 1859-60-61.)
	1862	MARTIN, J. H. C., M.D., M.R.C.S. Eng. & L.D.S. Cambridge House.

	Entered.	
Preston	1859	KYAN, JOHN HOWARD, L.D.S. Fishergate.
	1863	ROWE, H. R., L.D.S. 60, Fishergate.
Ramsgate	1859	ROBERTS, C. D., L.D.S. Memel House.
Richmond	1863	HEATH, T. W. 8, The Green.
Rochester	1863	ROBERTSON, J., L.D.S. St. Margaret's Bank.
Rome	1859	BURRIDGE, LEVI SPEAR, M.D., D.D.S. 5, Piazza di Spagna. (*Corresponding.*)
	1857	STATHAM, JOHN LEE, L.D.S., F.R.G.S. 29, Piazza di Spagna, and 6, Bedford Street, Bedford Square, London.
Scarborough ...	1857	VIZARD, EDWARD, L.D.S. 29, St. Nicholas Street. (C. 1863.)
Sheffield	1863	MOSELY, GILLAM, L.D.S. 205, Bath Buildings.
	1859	SHERWIN, J. J. 14, Surrey Street.
Southampton ...	1856	BROMLEY, CHARLES, L.D.S. 1, Portland Terrace. (V.P. 1857-58-59-60.)
	1863	PAYNE, J. P. 2, Sussex Terrace.
Southsea.....	1863	FORWARD, R., L.D.S. 3, King's Terrace.
	1862	WHEELER, J. Osborn House, Palmerston Road.
St. Columb, Cornwall..	1863	FARO, H.
St. Leonard's...	1858	RANSOME, ROBERT, L.D.S. 3, Verulam Place.
Stratford-on-Avon ...	1863	GAMBLE, J. G.
Switzerland ...	1860	KOLLIKER, PAUL ALFRED. 12, Stadelhofen, Zurich. (*Corresponding.*)
Swansea	1857	SCOTT, FREDERICK JAMES CLOUSTON, L.D.S. 9, Fisher Street.
Taunton	1861	FISHER, W. 13, Crescent.

	Entered.	
Torquay	1856	RODWAY, HENRY BARRON. Park Place.
	1860	RODWAY, C. A., L.D.S. Park Place.
Wakefield.....	1863	WAITE, W. H. South Parade.
Weston-Super-Mare...	1863	DEW, T. 2, South Parade.
Wolverhampton	1858	DE LESSERT, CHARLES GRIERSON, L.D.S. 10, Waterloo Road.
Worcester.....	1857	ROBERTSON, JAMES. 47, Foregate Street.
Worthing	1859	CATTLIN, W., M.R.C.S.Eng. & L.D.S. 73, High Street.
Yeovil.....	1861	HUNT, W., L.D.S. Pen Villa.
York	1861	CUSSONS, GEORGE. 33, Coney Street.
	1856	KING, JOSEPH, L.D.S. 33, Coney Street.

ANNUAL GENERAL MEETING.

Monday, January 7, 1861.

W. A. HARRISON, Esq., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Mr. Alfred Hill, L.D.S., 38, Euston Square.
Mr. James Kempe Devonshire, L.D.S., 17, Tavistock Street, Bedford Square.
Mr. Charles Bygrave, 3, Rue Lafitte, Paris (non-resident).
Mr. Daniel Corbett, M.R.C.S. & L.D.S., Dublin (non-resident).

The following Gentlemen were proposed for the Membership of the Society:—

Mr. G. Cussons ..... 33, Coney Street, York.
Mr. E. Truman ..... 23, Old Burlington Street.

The following Donations were made to the Society:—

Mr. Edwin Saunders, an Album for the Photographic Portraits of the Members.

Mr. Crampton, some upper and lower Maxillæ, taken from a Saxon burial-ground recently discovered at Long Wettenham, near Abingdon, supposed to be about 1,000 years old.

Mr. W. A. Harrison, a Clock.

The following Gentlemen were elected by ballot as Officers and Council for the ensuing year:—

President.—W. M. Bigg, Esq.

Vice-Presidents.—John Tomes, Esq., F.R.S.; S. Cartwright, Esq., F.R.C.S. & L.D.S.; Edwin Saunders, Esq., F.R.C.S.; John Martin, Esq., L.D.S.; T. G. Palmer, Esq., L.D.S.; Robert Brookhouse, Esq.

Treasurer.—Arnold Rogers, Esq., F.R.C.S. & L.D.S.

Honorary Secretaries.—T. A. Rogers, Esq., M.R.C.S. & L.D.S.;

Alfred Canton, Esq., M.R.C.S. & L.D.S.; G. A. Ibbetson, Esq., F.R.C.S. & L.D.S.

Council.—J. B. Fletcher, Esq., L.D.S.; T. Underwood, Esq., L.D.S., R.C.S.; H. J. Barrett, Esq., M.R.C.S. &. L.D.S.; W. A. N. Cattlin, Esq., F.R.C.S. & L.D.S.; J. R. Mummery, Esq., L.D.S.; S. Maclean, Esq., F.R.C.S.I.; John Drew, Esq.; J. Sheffield, Esq.; Alfred Coleman, Esq., M.R.C.S. & L.D.S.; J. R. M. English, Esq.; W. K. Bridgman, Esq., L.D.S.; G. Parkinson, Esq., L.D.S.; H. A. Dewar, Esq.; R. H. Moore, Esq., F.R.C.S.I.

GENERAL MONTHLY MEETING.

Monday, February 4, 1861.

W. M. BIGG, Esq., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Mr. J. Walker ..... 82, Wimpole Street.
Mr. W. May ..... 26, Guildford Street.

The following Gentlemen were proposed for the Membership of the Society:—

Mr. G. Laurie..... 26, Mortimer Street.
Mr. S. Parker..... 18, Colmore Row, Birmingham.

The following Donations were made to the Society:—

Mr. Owen, a curious set of Artificial Teeth of the last century, and Models of a case of Partial Edentition.

Mr. N. Stevenson, a collection of Skulls of various animals.

Mr. Samuel Cartwright read the following Paper

On Disease and Treatment of the Pulp.

On the first occasion of the meeting of this Society in this present session, a paper was read by Mr. Thomas Rogers, written by Mr. Bellisario, of Sydney, on the advisability of drilling into the pulp-cavity at the necks of teeth for the purpose of relieving the pressure of fluid secreted during ulceration or decomposition of the pulp-substance, or the inflammatory condition which so often succeeds when teeth have been plugged over

exposed pulps. As the subject excited considerable interest, I wrote the present paper, partly because I heard that no other had been forwarded to the Secretaries to be read at the second meeting of the Society, but principally for the sake of renewing discussion upon a point of much practical importance; but I found that one had been promised by Mr. Coleman, which I regret I did not have the pleasure to hear; but as that paper did not go into the subject of diseased pulps generally, I submit the present as then written, but with some additions, to the Society, and trust that in so doing I shall not be considered as intruding an oft-repeated tale on their attention. I have no idea of offering matter new to the profession, and have not confined my remarks to the late Dr. Hullihen's operation, but have considered the subject of diseased pulps generally, and the treatment which, from my own observation and experience, as well as such recorded by others, appears to be most likely to save the pulp, and failing that, to save the tooth.

It is not necessary to take up your time in going into the anatomy and physiology of the organ under consideration; but in order to make clear what I have to say, I will touch on those subjects so far as is necessary to assist demonstration. The pulp is a soft, pale-pinkish substance, containing cells, and their nuclei fully

supplied with vessels and nerves, and surrounded by a basement membrane which fulfils the office of a periosteum. It is generally adherent to the walls of the cavity in which it is encased, and appears to be, according to Mr. Tomes's researches, continued in the form of minute fibrils into the dentinal tubes; but it is especially adherent at the upper part of the cavity at the crescentic convex borders, and presents at the terminal points of the crescentic edges a character so prolonged and dense as to assume the office of ligaments, and which hold the pulp in position. It requires some force to tear the pulp from these points, so firmly is it attached.

Under circumstances of irritation, or by a gradual process extending over a course of years, the pulp becomes wholly or partially converted into what is termed secondary dentine by Mr. Tomes, osteo-dentine by Mr. Owen, and which in old age, or sometimes under peculiar circumstances at comparatively an early age, completely usurps the place of the pulp and fills up the pulp-cavity. This secondary dentine does not present itself in any regular manner, but is found in patches or points of ossification throughout the pulp-substance. Mr. Salter calls these patches "islands." These points increase in size, and join other patches, but often a considerable quantity of pulp remains between, and in dried specimens these patches appear isolated in different

parts of the membranous pulp-residue. In caries, and in teeth which are worn away by friction, exposing or threatening to expose the pulp-cavity, this secondary dentine forms readily at the point encroached upon.

The form of the pulp differs in different classes of teeth: in single-fanged teeth it is long and narrow, having tapering extremities; but in bi-fanged teeth, and multi-fanged teeth, it is broad and somewhat square-shaped at the upper part, which corresponds with the crown and neck, and tapers down to the extremity of the roots. The pulp-cavities coincide in configuration with the pulps. In the upper bicuspids and molars, and the lower molars, the cavity forms an irregular square, the upper border or roof, if I may so express it, being very convex; so that the superior margins of the four walls are crescentic, and consequently four sharp corners are formed at the points of union of the crescentic edges. Now, these crescentic points are those prominent parts which are most liable to be exposed in the process of excavating decayed cavities, both when decay exists in interstitial situations, and when it takes place on the masticating surfaces of teeth. On the molars, for instance, decay is found usually in two situations—in the depression in the centre of the crown, and in the posterior fissure, which is situate over the posterior crescentic points of the pulp-cavity. The former situation admits of

deep excavation, on account of the convexity of the roof of the cavity; whilst in the latter the points may be reached more readily, and in some teeth without any great depth of cavity being made.

The same remarks apply to the anterior and posterior approximal cavities in these teeth. The crescentic points are liable to be exposed when excavating the sides of the cavities.

We know that the pulp may be removed from a tooth, and the tooth may be plugged and retain its colour; but the sense of pain is destroyed, and vitality may be preserved in the root or roots through the vascular medium of the periodontum. We also know that a tooth may become gradually discoloured after the pulp is destroyed, and yet remain painless; but if inflammation set in, so as to destroy the periodontum and periosteum of the socket, then the tooth is always troublesome, either owing to inflammatory symptoms, or a necrosed condition of the walls of the socket, or from the irritation consequent on the contact of a non-vital organ with a vital one. We may reasonably infer that nervous sensation is communicated to the tooth by means of the pulp, and that the vascular supply is furnished to the crown of the tooth through the agency of the pulp; but that the vitality of the root or roots is preserved, independently of the pulp, by the vascular supply through the periodontum, which

is furnished by the alveolar arteries. Roots will retain vitality and go on increasing in size by deposition of cemental substance long after the crown has been lost through caries.

The pulp may be affected in three ways without manifesting symptoms of inflammation: irritatively, but without contact with decayed bone, probably by infiltration or nervous communication through the organized contents of the dentinal tubes; irritatively, but in contact with decayed bone; and irritatively from positive exposure to external influences.

I have known cases of irritation of the pulp where only superficial decay existed, but where there was experienced severe pain, simulating violent toothache arising from acute inflammation. In two cases which I call to mind the pain was so severe that the patient called with the idea of losing the teeth; the affected teeth being a bicuspid and a molar, both of the upper jaw, the decay interstitial. In one case the decaying bone did not exhibit any extraordinary sensibility; in the other, the dentine was very sensitive on touch. The removal of the decayed bone in the least sensitive tooth, the molar, and the partial removal of the decay in the other, followed by the application of morphia, protected by a plegget of cotton wool dipped in mastic solution for a few hours, removed the pain, and the teeth were plugged with gold-leaf without trouble on the

following day, and have remained free from pain. It is by no means unfrequent to meet with long-standing decay, especially in the denser kind of dentine, where pain and evident irritation exists in the pulp-substance, often evidenced by irritable sensation rather than defined pain, and these cases are mostly amenable to treatment; or in other words, we may induce, by stimulative applications, those conditions which not unfrequently spontaneously occur; for where decay is gradual, and the affected bone hard and dry, it is not uncommon to find the pulp partially, if not altogether, ossified; at all events, the dentine immediately covering the cavity, although dark, will be found excessively hard, and the probability is that the ossification of the contents of the tubes, which appears to account for this density, is coincident with calcification of the pulp; as soon as the surface exposed is covered by a plug the irritation subsides.

Where irritation exists, the result of contact of decayed and soft bone with the pulp, pain is the result of the pressure of air or food, the effects of cold or heat, or of acrid secretions, either of the mucous membrane, or more generally and probably the acridity arising from stagnant mucous secretion retained in the cavity of decay, and infiltrating through the spongy bone, or the decomposition of animal substance taken as food, &c. In such cases it is not desirable to attempt

the removal of the whole of the decayed bone—a proceeding which would of necessity expose the pulp; but the upper part of the cavity may be cleared out, freeing the walls thoroughly, and leaving intact the soft bone which lies over the pulp-cavity; and after thoroughly drying, a fairly compact filling may be made with tin, or gold even—Hill's or Jacob's stopping, either with or without a cap, as the case may be.* The exclusion of air and moisture speedily relieves the symptoms of irritation, and after the lapse of months or a year, the temporary filling may be removed, more decayed bone taken away from the floor of the cavity without painful sensation, and the tooth properly and safely refilled. In most cases it will be found that decay has made little if any progress during the probationary period, and often, instead of being soft, moist, and flaky, it will be firm and dry; and this condition is doubtless more likely to be constant if previously to the temporary filling a small quantity of tanning is inserted. When much sensation exists in the affected bone, and when the slightest pressure is unbearable, then the application of morphia, alone or combined with sal volatile or spirits of wine; morphia and creosote, or oil of cloves; sulphate of atrophine; tannin and creosote; sulphuric or nitric ether, or chloride of zinc; and

* When this paper was written the combination of zinc fillings, although known, had not been generally tried.

Mr. Drew's compound, consisting of quicklime and magnesian limestone (introduced to the notice of the Society at a former meeting), act beneficially in allaying both the extreme sensitiveness of the dentine and irritability of the pulp. Tanning has doubtless the effect of hardening the decomposed bone by combining with the animal tissue, or, more properly speaking, through the affinity which gelatine has for tannic acid.

Not unfrequently patients are their own doctors; and persons suffering from severe toothache fly to that unpleasant column of the *Times* advertisement sheet where cure for toothache is promised in an instant, and send for the bewitching mineral succedaneum "known only to the advertiser," and which, immediately on receipt, they apply according to direction: they insert the magic filling recklessly, of the physiology of nerves and pulps possessing happy ignorance, in the midst of decayed bone, and even over partially exposed pulp; and often, strange as it may appear, without those results which so often harass the practitioner and puzzle his ingenuity. The reason of the success is easily solved: the pulp, although exposed, is not inflamed; the non-removal of decayed bone protects the pulp from immediate contact with the filling, and the patient goes free, for a time at least, rejoicing in and singing the praise of the mineral compound. I have found, on removing this amateur filling in

certain cases, either for the purpose of refilling properly, or because it had become loose, after remaining in for periods ranging from weeks to a year, that little sensation existed, and have removed decay and filled the cavity without causing pain, the pulp having been either removed by painless ulceration, or comparatively so, or partial ossification having taken place in its substance. I have referred to these cases because they innocently confirm the value of our practice of temporarily filling tender teeth, for the purpose of giving Nature time to provide against the encroachment of decay by pulp calcification, or to arrest the progress of decay by excluding air and moisture, or to allow of the obliteration by deposit of ossific matter within the affected tubular structure—a physiological fact so clearly and correctly demonstrated by Mr. Tomes.

There can be no doubt that teeth which present generally sound and dense structural development, and in persons of robust constitutional diathesis, the pulp calcifies more readily than in others whose teeth are more delicately organized, and whose constitutional powers are less vigorous and healthy. Teeth which are gradually worn down, exposing the pulp cavity with its ossified pulp, we find, as would be expected, are in structure dense, and of that pale yellow colour which characterizes good strong teeth. The jaws and oral cavity coincide with the teeth—being,

as it is termed, well pronounced, well arched and wide, the external and internal plates of the lower maxilla thick, and the cancellous structure dense, as in the Celts, or elliptic and deep, as in the Scotch and north-country people.

The teeth, too, of those persons, which are worn away by pressure of the pipe, retained by habit between the same teeth, are always of good quality, the enamel thick, and the dentine dense. We never find delicate-structured teeth worn away with ossified pulp-substance showing, or the circular opening where the pipe is carried, in mouths the teeth of which are delicate. Absorption of the alveolar cavities takes place from the pressure of the opposed teeth in the one case, and the pipe is shifted about in the mouth in the other, on account of the uneasiness produced if it be retained too long in one spot.

These facts lead to the conclusion that teeth presenting good structural features, and which belong to a sound constitutional diathesis, are more likely to be treated successfully if decayed, and if decay have progressed so far as to implicate the pulp; but that others, in which structural formation is indifferent, and the general condition of the system shows want of tone and power, the chances of inducing by local treatment the calcifying of the pulp are very problematical. Passive or active irritation in neighbouring structures will induce cemental increase, and likewise pulp cal-

cification; and in many instances we find the two phenomena co-exist, as may be proved by splitting or sawing through teeth which present abnormal thickening of cement substance. A certain amount of irritation appears to be necessary to induce the pulp to ossify prematurely, which irritation may arise from some physiological condition of the teeth themselves, or from disease of the tissues or bone of the jaws. But this subject is pregnant with interest, and will admit of still further investigation, although the researches of Mr. Salter and Mr. Tomes have gone far to elucidate it. As far as a single illustration is admissible, the latter phenomenon is shown in a specimen on the table—*a longitudinal section of a lower anterior molar tooth*, which I removed from a diseased jaw previous to operation, and to which I referred on the occasion of Mr. Bellisario's paper being read. You will see that cemental substance is largely developed, and secondary dentine occupies the entire pulp-cavity. The tooth was situated in bone much influenced by the disease of the gum tissue, which turned out to be fibrous tumour. The two bicuspids, which I also removed, were out of the sphere of the disease, and were normal in regard to their roots and pulps.

Some four or five years ago, I filled a lower molar tooth for a young lady about twenty-two years of age. (The preparation is on the table.)

It had been tender, but there existed neither looseness nor sign of inflammatory action. Excavating the decayed bone was painful; but the pulp-cavity I know was not reached. The tooth, when filled, was perfectly easy; and since that time I filled two other cavities. She married, and, as is common, suffered much from neuralgic pains in the teeth and face during pregnancy. I may add, too, that she was subject for some years to true neuralgic affection—the result of a violent concussion of the face with the side of a carriage which was overturned, the horse having run away—and is somewhat hysterical. About nine months ago she suffered much from lancinating and throbbing pain, and the posterior molar tooth, left side, was loose and sensitive on striking with steel; it had been some months previously filled with Hill's stopping on the masticating surface, the bone being peculiarly sensitive, but the pulp-cavity was not reached by decay. I removed the tooth at length, at her repeated and urgent request, and found the pulp healthy in appearance, though somewhat larger than normal, and slightly congested. After the first day she lost all pain. About three months ago she had a severe attack of sharp, lancinating, diffuse, and throbbing pain. The tooth which I first referred to, the anterior molar, became loose and tender, and there was some sympathetic swelling. Soon the pain subsided, and the tooth

became firm. Nine weeks ago she had a similar though more aggravated attack, accompanied by similar symptoms. Two months back I removed the tooth, and on dividing it with a saw, I found that the pulp was three parts or more ossified, with one piece of irregular and several isolated nodules of secondary dentine; the cavity and canals of the roots were filled with thick and offensive fluid, the residue of the decomposed remnant of the pulp. There was, you will see, no communication between the decayed cavity and the cavitas pulpæ. It is manifest that the pulp had been long diseased; but it is a curious fact, considering the condition of the pulp, that four years or more should have passed without pain being felt in the tooth. I have now no doubt that drilling into the pulp-cavity at the neck of the tooth would have relieved the symptoms, for three weeks ago this same lady suddenly suffered from severe lancinating, darting pains in the upper right anterior molar, which had been filled for some time, and which, up to that time, had been perfectly easy. There was no external appearance of inflammation, but the nature of pain indicated pulp irritation. I may state that I ascertained she was with child. I did not in this case remove the tooth, although she much wished it, but drilled into the pulp-cavity. She suffered for ten minutes most intense pain, which satisfied me that acute inflammation existed in

the organ; but the tooth was free from sensation on the following day, and has remained so since.*

The difficulty heretofore and generally experienced in treating diseased or exposed pulps has been naturally great, and often all our efforts are unavailing. The delicate organization of the substance, and the unyielding nature of the structure which encases it, render the mutations from irritation to inflammation, and inflammation to ulceration and gangrene, so rapid, that local applications have not much chance; whilst temperament and constitutional tendency often render treatment nugatory. Despairing, therefore, of saving the pulp, and vexed by frequent disappointments, practitioners have adopted the total destruction of the pulp, either by removal by instrument or by the use of escharotics; the feasibility or rationale of the plan being warranted by the vascular connection which exists between the periosteum of the socket and the periodontal membrane. I have brought with me a specimen which shows a vascular connection through the tooth substance with the pulp itself—a connection which I expect is not unfrequent; and since writing this I have read a paper by Mr. Mc Quillen, in the "Dental Cosmos," which men-

* I have seen this case twice within the last few months, pain and uneasiness being felt in the tooth; but by passing a small broach through the opening made into the pulp-cavity, ease has been given.

tions cases of vascular permeation of the cement and dentine, and the communication which exists between the periodontum and the pulp. But unless the whole of the pulp be removed, or the remnant remaining in the root be allowed to heal, so that no secretion is formed, or to become removed by ulceration, it is useless to fill the cavity solidly. The secretion formed, either in the shape of pus or fluid, by the remnant of the ulcerated or decomposing pulp will, as is well known, by pressure induce inflammation of the periodontal membrane, or having no outlet excepting by the small opening at the extremity of the root or roots, the fluid becomes but gradually infiltrated between the root itself and the periodontal membrane, inducing a train of symptoms which terminates in what is called alveolar abscess.

If we can get rid of the remnant of pulp situated at the lower portion of the canal in the fang, and all secretion, before the periodontum has become implicated by disease, the cavity of decay may be filled, together with the entire cavity in the root, and sometimes of a portion of one or more of the multi-fanged roots of the molars, and success repay time and trouble. I cannot bring myself to believe in the possibility of completely filling up the whole of the three roots of a molar tooth.

It is a question still as to the time expedient to elapse before attempting to fill after the pulp's

artificial destruction, and in this we can only be guided by circumstances. Persons in good health, and of phlegmatic temperament, are more easily manageable as respects operative treatment on their teeth, than delicate persons or persons of irritable temperament. I have more than once filled over an opening into the pulp-cavity, made during excavating (when the crescentic edge of the cavity is prominent), without untoward results, knowing my patient; but to adopt a practice generally founded on an occasional successful issue in such cases, would subject one to continual disappointment and patients to grievous pain and probable loss of teeth. Some of the most permanently successful cases which I have had, have been those in which I have allowed ample time to elapse between the period of destroying the pulp and the insertion of the permanent filling; the time varying from two to six and eight months. With me, too, the treatment of upper molar teeth (I mean, when roots have to be filled as far as possible, as well as the cavities in the crowns) has been more successful than lower molars, and, as would be expected, single-fanged teeth than bi- or tri-fanged teeth. I attribute this to the difference of density of the two maxillæ, whereby absorption of the alveolar parietes more readily takes place in the superior maxillæ than in the thick plates of the inferior bone. Teeth will often answer well when filled on the day

following that on which arsenic has been applied. I saw, not long ago, a gentleman for whom I destroyed the exposed portion of the pulp of a lower molar tooth, and filled it in with gold on the following day, now some nine years back. He has not experienced the least annoyance from the time it was done; for the last year or so it has been loosening, probably from absorption of the alveoli and of the fangs, but it is still quite serviceable, and he was not aware that it was loose.

Of all the escharotic agents used for destroying the pulp substance, there is none that seems to answer so well as arsenic, either used alone, or in combination with essential oils—creosote or oil of cloves and morphia; but other substances are used, such as chloride of zinc, hydrate of potassa, mineral acids, sulphate of copper, perchloride of iron, nitrate of silver, cobalt, which I have not used, but which is strongly advocated by Mr. Arthur, on account of its containing arsenic in great quantity—some 60 per cent.—and its insoluble nature, and the actual cautery, much used abroad; and when the wire can be applied with facility, its application is very satisfactory. I have so treated teeth in my own practice with much success, and having seen many in which the plan has answered well; and, lastly, the cautery by galvanic action, introduced into surgical practice by Mr. John Marshall, of

University College Hospital, used with success, and highly spoken of by Mr. Harding. The pulp may be partially or wholly removed; but when partially so, there is danger of subsequent irritation after filling. The entire pulp may be removed either by re-applications of caustic or the use of the nerve-drill, or the passive treatment—that which allows time to effect the gradual removal of the pulp-remains, assisted by the application of alcoholic mixtures and sedatives. In single-fanged teeth, the pulp may often be removed entire by means of a twisted or barbed drill; and these teeth, when filled up solidly throughout the length or the greater part of their canals, succeed most perfectly, on the same principle as pivoted cases succeed so well, the vascular connection with the alveolus preserving the vitality of the roots for years. In many cases of exposed pulp, or pulps exposed during excavating, it is not possible, owing to the situation of the decayed cavity in interstitial situations,—for instance, at the neck of teeth,—to apply the drill, or even to re-introduce escharotics so as to lie in contact with the pulp; take bicuspides or molares for instance, the crowns of which are large, and the necks constricted. These cases admit of the Hullihen operation of trephining or drilling into the pulp-cavities. Dr. Hullihen performed the operation at the time of filling a cavity in which the pulp was exposed, not previously attempting

to destroy it by arsenic or otherwise. He filled over the pulp, opening into it immediately before filling at the neck, just below the level of the gum, or through the gum and alveolus, and so afforded relief by bleeding, or got rid of the pressure of fluid exuded in the inflammatory stage if it set in; but his object was to avoid the risk of inflammation and destruction of the pulp. Drilling into the pulp, when inflammatory action or decomposition has set in, is for a purpose different from Dr. Hullihen's object; his was to save the pulp, the latter relieves pressure by affording an outlet for pent-up matter after the pulp is compromised, and so saves the periodontum from being involved in inflammation and suppuration. For the same object contrivances have been made, and Mr. Barrett is in the habit of using, or did use, a tube with a piece of gold plate soldered to one end, and which was placed over the opening into the pulp-cavity; he then filled over this shield and around the tube, so that an artificial opening was formed for the escape of fluid; or the simple drilling through the filling often answers in like manner. I have for some time past, previous to filling, especially in teeth where the bulk of the pulps are destroyed, but in which moisture or fluid passes up the canals, inserted in the canal, or one of the canals, depending on the class of tooth, a piece of gold wire, or a broach reduced in temper, and filled round it

with amalgam filling, and then removed the wire or broach, leaving a free but small canal for escape of fluid, and the plan answered very well; but I think the drilling at the neck, on a level or just under the gum, which is effected by pushing its edge down with the drill previous to rotation, is a neater way of insuring the same end, and has the advantage of not interfering with making a perfect filling. The plan of capping over exposed pulps with gold, lead, ivory, and other non-conducting substances, without attempting previous partial destruction, is advocated by many practitioners, and is successful in a sufficient number of cases to warrant its adoption; but it is a useless proceeding if inflammation have set in, or if an unhealed eschar be present, or if fluid or pus exude from the pulp's surface. Mr. Thomas Rogers, who has had much experience in such practice, tells me that he believes one-fourth of the cases he so treats succeed.*

We cannot give too much attention to the consideration of the best and surest means by which the pulp may be preserved; for I think we all admit that the preservation of so important an organ is *the* point to be aimed at; but if the pulp be exposed and inflamed, removal of the whole

* In these cases I have found the zinc preparation of much use; and of late in my own practice and at the Dental Hospital have filled, or directed that a filling should be made over an exposed point of pulp; a non-conducting medium, such as paper or other material, being placed between the filling and the point of exposure.

is necessary, for in the great majority of cases, no amount of pains of the practitioner will in the end save the organ, and my experience of capping in such cases is far from satisfactory. .

If decayed bone, as I have said before, have extended to the pulp, but without exposing it, the portion covering may be left, and the tooth filled, and remain useful for years. Years ago—twenty and more—my father said, "Don't expose the nerve; get out as much decay as you can, and fill the tooth as perfectly as you can, and it will answer." Mr. Arthur states, in his excellent work on "Treatment of the Pulp," that he has not always found it necessary to remove all the decomposed bone from a cavity, and that he has found, on removing filling at the end of a year, which he inserted for temporary purposes, that decay had been stationary.

In cases of extreme sensitiveness, when decay has evidently extended to the pulp, and its contact produces irritation and a congested condition of the vessels at the point of contact, tannin, or tannin and creosote, act satisfactorily. I have often filled temporally with the leaf or Hill's stopping over a piece of cotton-wool moistened, but not saturated, with creosote or other essential oil, or spirit of wine, or ether, on which was taken up tannin, and had reason to be satisfied with the results; and when the irritation has subsided, I have removed the temporary stopping, and first

inserted a thin layer or coating of amalgam, which, when hardened, I have filled over with gold leaf. I may say that one considerable advantage attends the plan of casing the cavity of decay with amalgam; viz., the facility with which it way be drilled through should inflammation supervene. I have but lately seen teeth which I treated years ago in that way, and which are still perfectly comfortable, the filling sound, the gold portion not being affected in colour or compactness. In cases such as these we have fair grounds to suppose that calcifying of the pulp will take place, at all events in some. We occasionally meet with teeth in which secondary dentine has formed under the decayed bone of unfilled teeth.

I have referred to a case in which ossification of the pulp partially took place in a tooth when decay had not reached the pulp-cavity, and in which destruction of the remains of the pulp subsequently occurred.

The peculiarity of the pain experienced in that tooth, and in the one previously removed, where evident irritation existed in the pulp, and which, judging from the sequel of the other, I have little doubt would have evidenced a similar train of symptoms had the tooth not been removed, induces me to draw your attention to the subject of calcified pulp, as presenting distinctive symptoms which may possibly guide us in forming a

correct diagnosis of that condition when it is present in an abnormal form, or, in other words, when the age of the patient is not such as ordinarily to exhibit the phenomena of pulp-calcification. Mr. Catlin called the attention of the Society to this subject at a former meeting, and tells me that lately he has had two well-marked cases occurring in teeth, the pulps of which are perfectly ossified.

There exists often an undefinable sensation not amounting to pain, but very constant in character, in teeth worn down, or in which decay has been arrested naturally, and in which conversion of the whole substance of the pulp into dentine has taken place. Patients describe an itching, irritable sensation, and say that pressure firmly made on the tooth appears to afford relief; no looseness is apparent, and the gums are not swollen or preternaturally red. I remember a case of a gentleman—one out of several—who complained for two years of inconvenience felt in an upper posterior molar. The ossified pulp was exposed. The increase or decrease of sensation was influenced by his state of health, but he was never without the knowledge that he had that tooth, and at last I removed the tooth. There was some abnormal deposition of cement, but not sufficient to account for the sensation. There was, I may remark, no antagonistic tooth; but there was not extrusion of the affected tooth, as is often the case when an opposing tooth is lost. But calcified

pulps are very frequently met with when no marked sensation existed in the tooth, and the teeth are removed on account of irritation arising from a thickened condition of the periosteum, or the very abnormal deposition of cemental substance.

When irregular, dark-coloured, nodulated, and isolated patches of secondary dentine exist, the pulp is in many instances diseased, and the termination of such a condition is gangrene and destruction of the bulk of pulp substance. The train of symptoms are specially those of irritation—sharp, darting, jumping, neuralgic, or, as it is often well described, stabbing pain, intensely severe, but not of long duration; and certain peculiar characteristics are present, viz., absence of general inflammatory symptoms, looseness of the tooth, and freedom of, or but slight, sensation on striking with an instrument; but similar symptoms exist when, as occasionally happens, the unexposed pulp inflames and becomes gangrenous without previous calcification. Two cases have lately come under my notice bearing on this point, occurring in teeth which had been filled some time, and which had given no uneasiness—both upper molars, one being a second, the other a wisdom tooth. Pain came on suddenly, and with severity, during the late severe frost; in the first case, the tooth was tender on striking or pushing from side to side, but this was accounted for by

recent inflammation of the periodontum. In the other, no periodontal thickening was observable, but the tooth was sensitive on touch. Each of the teeth was filled with amalgam, and the cavities of decay were large. It is possible that, on account of the large surface filled, the pulps were acted on by cold. The situations of the teeth prevented the ready use of the drill, so I removed them. Now, I think we may safely diagnose a gangrenous condition of pulp from the particular train of symptoms, and may surmise as possible an irregular calcification of the pulp; but the question is, whether the severe train of symptoms will be constant in calcified pulps or partial calcification when the rest of the organ is normal as to condition. I am inclined to say that disorganization of the residue of pulp substance must be present, or at all events impendent, before such marked pains are experienced, and possibly the membrane intervening between the primary and secondary dentine may become inflamed, and be the seat of pain.

We must all of us have had occasion to be puzzled and worried by patients returning, after the lapse of a few days or a month, complaining of pain in a tooth which had been filled, after much time and trouble had been bestowed upon it. In former days the practice was to get rid of the difficulty by removing the tooth; now people are not so fond of losing their teeth, and attention on the

part of practitioners has been directed to the means of saving teeth, which a few years ago would have been considered a hopeless attempt. With patience, and if our patients also will have patience and give the necessary time, teeth may be so prepared as to bear filling successfully when much affected by caries; but it is not one out of fifty who will take the trouble to go through the ordeal necessary to accomplish the end—either of inducing by time or stimulants calcification of an exposed pulp, or the cessation of exudation of fluid, if a pulp have been destroyed as far as is possible. That such can be accomplished when a fair chance is afforded, there can be no doubt; but, with all our endeavours, we cannot, and do not, succeed in all cases.

The published practice of the late Dr. Hullihen has unquestionably opened a path by which we may be led to more satisfactory results, and his practice is well worthy of consideration and imitation. The notion of drilling through fillings, to afford escape of fluid, and of drilling through the healthy bone into the pulp-cavity at a point away from or below the filling, is not new. Mr. Harrison stated, on the occasion of the discussion on Mr. Bellisario's paper, that he had often drilled into the pulp-cavity for the purpose of relieving the pressure of fluid, before Dr. Hullihen published his paper; and my father tells me that many years ago he saw a tooth that had been drilled in a

similar manner, and for a similar purpose, by a dentist residing abroad, and that the operation was successful; but it certainly was an operation very rarely performed, and I do not think ever with the object Dr. Hullihen had in view, and not by practitioners at home or abroad at all as a rule; but it is, I believe, a valuable operation, simple, and one which will be the means of alleviating much suffering and saving many a tooth. In cases of peridental irritation or inflammation succeeding the filling of cavities when the pulp has been reached, it enables the practitioner to get over one of the most tiresome difficulties connected with conservative dental surgery, and saves the annoyance of having to remove either fillings which have but lately been inserted, after long preparatory treatment, or the teeth. I have, within the last three or four months, treated numerous teeth in this manner, and in every instance relief within a short time has been afforded. So many cases occur in practice when, from circumstances, it is not possible to undertake a course of treatment which will secure a probably successful filling. Patients often are passing through town, or come up for a day only, and reside so far off that they are indisposed to undertake repeated journeys; or their avocations may be too important for them to give up the required time. Under such circumstances, the operation enables us to fill the tooth at once, with a reason-

able conviction that after inflammatory action will not take place.*

At present I have not found it necessary to stop even with cotton wool, at the time, the drilled opening; and as all the cases which I have seen, and which had been operated on some considerable time back, were left open, I am not inclined to attempt the filling up the cavity, unless I find, as in Mr. Ballisario's case, that pulp calcification had taken place, especially as no indication of caries presented in any one case. I find a small broach, short enough not to bend, sufficient for the purpose.

As an illustration, I will mention one case. About ten months ago, I filled, after treatment by tannin and spirit, an upper anterior molar, for a gentleman, with gold; it had been very painful. Between three and four months back he called, having experienced very sharp pain for two days past, which came on suddenly, and which he attributed to being exposed to cold and damp. The tooth was slightly loose and tender when moved from side to side. I did not remove the filling, which was quite firm and solid, but drilled into the pulp-cavity at the neck of the tooth. He

* I have had opportunities of seeing some of the cases within the last month or two, and they may be pronounced successful, although it cannot be said that the teeth were always comfortable; but the pain experienced was not severe, was periodical, and occurred at distant intervals; being instanced by tenderness or pressure, rather than decided pain.

complained of sharp pain as the instrument entered the cavity, but none was felt a few minutes afterwards. This patient was to call if pain were experienced; but I have not seen him since, and I doubt not that he has found relief from the operation. I can bear my testimony to recorded facts, that exposed pulps may be filled over and all the pressure necessary for gold filling applied, without the patient suffering pain, immediately after the operation of risodontrophy, as it is termed, has been performed, when the slightest pressure previously was unbearable.

I fear I have severely tried your patience, but I cannot conclude without acknowledging Mr. Catlin's kindness in supplying me with a considerable number of teeth, most of which he took the trouble to have previously sawn through; but I have not been able to make all the use of them I could have wished. Many go to show that there is truth in what I have asserted in this paper, and in what others have asserted before; but I hope next session to be able to give some statistics formed from the examination of a large number of teeth, both dry and fresh, which may prove interesting and serviceable. I may say, that out of four hundred and fifty or more teeth, one hundred and twelve or more have partially or wholly ossified, and probably many more; but, being dry teeth, many specimens of nodules of secondary dentine may have been spoilt in splitting or sawing

through. Many nodules have dropped out since they were cut, I know. Several show that the pulps had been destroyed by ulceration and gangrene, before there was a chance of secondary dentine forming. I have brought down the teeth with pulp calcification; but careful classification is necessary before they can become of practical value.

GENERAL MONTHLY MEETING.

Monday, March 4, 1861.

W. M. BIGG, Esq., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Mr. George Cussons, 33, Coney Street, York (non-resident).

Mr. E. Truman, 23, Old Burlington Street.

The following Gentlemen were proposed for the Membership of the Society:—

Mr. H. H. Hayward, 56, Queen Ann Street.

Mr. R. E. Stewart, 37, Rodney Street, Liverpool (non-resident).

The following Donations were made to the Society:—

Mr. Bridgman, preparations illustrative of his paper on "Caries."

Mr. Drew, a model and portion of superior Maxilla from which it was taken, illustrating the effect of filling the anterior Molar with amalgam.

Mr. W. M. Bigg, Owen's "Odontography," 2 vols.

Mr. Bridgman read a paper

On Caries and its Treatment.

There are few points connected with the practice of dental surgery which have given rise to so much conflicting opinion as the cause of decay.

Its precise nature and origin have long been a disputed question. It has been regarded, by one section of the profession, *not as disease*, but as being entirely due to the effects of *external chemical action*,—that is, produced by the solvent power and corroding effects of some acid, generated in

decaying food, lodged between and around the necks of the teeth, and finding access to the dentine, through natural or artificial openings in the enamel.

Another section, viewing the teeth as organic bodies, having a strong analogy to ordinary bone, consider decay as a disease, resulting from morbid action upon a vitalized organization.

It is scarcely necessary to observe that these hypotheses, neither separately nor combined, are sufficient to account for decay in all its various phases; and that some further explanation is needed to satisfy the main bulk of the profession.

When these views were first promulgated, so little, comparatively, was known of the minute anatomy of the organs, and histological science all but unknown, that whatever opinions were held on the subject could be only little more than mere conjecture.

Our knowledge of the true structure of the teeth dates back but a very few years. The *re*-discovery of the dentinal tubes by Professor Retzius, of Stockholm, within the last thirty years, may be said to have been the commencement of a new era in the study of dental physiology. I say the *re*-discovery of the dentinal tubes, because, from a paper in the "Philosophical Transactions" for 1678, it would seem that these were first observed by the celebrated Leuwenhoeck; but as the lenses employed were simply minute globules,

melted from the end of a fine glass thread, and far more difficult to use than to make, there would be but few observers, and consequently the discovery appears very soon to have been lost sight of. On the introduction of the instrument in a more improved form, we had the announcement of the above *re*-discovery as one of its earliest results. The extraordinary degree of perfection to which the achromatic microscope has now been brought not only enables us to verify this discovery, but also even to determine the construction of the tubes and the materials which bind them together. In addition to this, it has fallen to the lot of one of the founders of this Society to be the first to announce the nature of the *contents* of these tubes, and to point out their evident connection with the central pulp; thus tending, in some measure, to confirm the opinions of those of our predecessors who, although unable to establish the *fact* of *vascularity*, as commonly understood, were evidently convinced of an arrangement existing which so nearly resembled that of other bones as to merit the same title.

If we turn to the writings of Hunter, we shall find this great physiologist, although compelled, by the result of his experiments with madder, to admit "tooth-bone" to be unlike ordinary bone, was yet unwilling to give up the idea of the teeth being vascular, and concludes by observing "*that they have most certainly a living principle, by which*

means they make part of the body, and are capable of uniting with any part of a living body."

Five-and-twenty years later, we find his successor, Fox, ignoring the result of these experiments, and boldly maintaining that, from their vascularity, the teeth were similar to bone, and differed only in being denser and having their exposed surface covered with enamel.

Dr. Blake, too, in 1801, in stating his opinion, says that vessels, both "circulatory" and others, are present in the tooth, and that minute vessels pass into the ivory. That the teeth are both osseous and vascular is also asserted by Professor Bell, who further states that there is a vascular communication maintained between the pulp and the ivory. Thus, from the time of Ambrose Paré, in the latter half of the sixteenth century, to that of the author last named, we have a period of near 300 years in which this belief, with but few exceptions, will be found to have been the prevailing one. And, believing the teeth to bear so close a resemblance to ordinary bone, it is but natural that the diseases of the one should be considered analogous to those of the other, and that, as true bones are subject to inflammation, the bone of the teeth should be so likewise, and therefore that gangrene, or mortification, or suppuration, should be the result.

When, however, it came to be noticed that the tubes of the dentine were too small to admit

the passage of the red corpuscles of the blood, and consequently believed that there could be no true inflammation, according to the true acceptation of the term, which implies *heat*, *redness*, and *swelling*, its probability, or even its possibility, began to be doubted, and other suggestions were then made as to the probable origin of the decay. The constant presence of acidity in softened dentine, together with the disappearance of its earthy constituents, would naturally lead to the supposed presence of the acid being the cause of decalcification. And that it might arise from decaying food would also present itself as the most feasible solution of its source; but it has never yet been shown how it would be accomplished. On a superficial view, it may seem extremely plausible; but on a closer investigation, it will be found to be quite as untenable as its predecessor. But as we have to consider the several components of the teeth in their elementary form, it will be needful to see in what their peculiarities consist, and how far each one can lay claim to the possession of *vitality*.

We must first, however, ascertain the conditions and appearances which are supposed to indicate the *possession* of vitality, and then see what are the laws and attributes of *vitality* itself.

If, on paying a visit to the seashore, we pick up a pebble and examine it closely, both inside and out, although we might find it to contain

traces of once living forms imbedded in its substance, we should soon come to the conclusion that the stone itself had never been possessed of vitality. If, on the other hand, we were to direct our attention in a similar manner to a piece of water-worn shell, we might possibly be at a loss to form an opinion; but if, instead, we light upon a piece of *Fucus vesiculosus*, or any of the larger seaweeds, we should unhesitatingly pronounce for organization and a living existence. If we inquire the reason, we find it at once in its structural arrangement—in the apparent presence or absence in its interior of *cell-formation*—that is, of cells or their derivatives.

This cell-structure, whether it exist in the plant or the animal, is looked upon as the basis of organization, and any form having it is known to possess organization. This in the seaweed is unmistakable, in the shell obscure, and requiring peculiar manipulation to make apparent, and even so it is rendered doubtful whether such appearances are not due to some other source. We have been accustomed to consider the solid constituents of shell and bone as consisting of these cells calcified—that is, formed first in the ordinary way, and then subsequently rendered solid by being filled up with their earthy contents, so as to form a dense and compact mass. This supposition is now likely to be set aside through the beautiful experiments of Mr. Rainey. In his work

on "The Mode of Formation of Shells of Animals and of Bones, &c.," the writer observes, "that by a proper employment of chemical and mechanical means, and by an exact adjustment of the condition under which they act, calcareous bodies, identical in structure and similar in composition to the elementary forms of the structures above mentioned, can be artificially produced;" and "that wherever natural products are found identical in structure with the artificial ones, the existence of *physical* and *chemical* conditions, similar to those associated in the artificial process, can be demonstrated."

To produce these calcareous globules, or artificial calculi, some mucilage of gum-arabic, containing a solution of carbonate of potash, and another portion of simple mucilage in water, are placed one above the other in a small phial, so that the lighter one may float above the denser; and the two becoming mixed gradually, give rise to a slow decomposition, which results in the formation of the bodies in question where the two fluids meet.

"From this process there results the simple, though very important fact, that when the carbonate of lime thus formed is in a viscid material, its form, in the place of being crystalline, as when produced in the same manner in pure or common water, is globular, and possesses in a remarkable manner the property of coalescing with contiguous particles of the same compound, as well as

of intimately blending with such substances as, in its molecular state, it may happen to be brought into contact with." But, says the same author, "the animal basis left after the decalcification of bones and shells has generally been regarded as a proof of their vital origin;" therefore it is contended "that, as exactly the same effect is produced by a like treatment of *artificial* calculi formed in a solution of *albumen* in the place of gum, this can no longer be considered as an infallible test of an organic formation."

Hence, by the advocates of the external chemical action theory and non-vitality of the dentine, this theory will be taken as conclusive evidence in favour of their own views; but a closer consideration of the subject will show that it does not alter the position in that respect in the slightest degree; for whether we grant the solid material of the bone to be formed by molecular coalescence, as propounded by Mr. Rainey, and thus owe its origin wholly to physical action, or whether we abide by the cell-development theory, and attribute its solidity to the transformation of cell-contents, the main features of the case remain identically the same.

We have a definite amount of an organic body intermixed with an *in*organic and crystalline substance of a peculiar character, for the specific purpose of rendering it hard enough to withstand the mechanical action of mastication. Now,

whether we consider the crystalline element as filling a previously prepared envelope, or whether we admit the membrane and the crystals to be formed simultaneously, it is perfectly immaterial, as regards the possession of vitality by the substances in question; for no difference in arrangement or in external appearance can in any way interfere with its still remaining an *organic*, or, in other words, a *vital* body.

In the error of confounding a *vital body* with *vitality*, *vital activity*, or *vital action*, all the mystery and confusion regarding the vitality of dentine would seem to have had its origin, and than which nothing can be more separate and decided.

"If we take a portion of albumen from the egg," says the author of "Physiological Riddles," in the *Cornhill Magazine*, "it is a vital substance. It possesses life. Yet it possesses no power of performing actions. It has no defined shape, and has not even any kind of structure; nevertheless, it is living, and that which constitutes it living is the mode in which its elements are combined. It consists mainly of three gases (hydrogen, oxygen, and nitrogen), and one solid (carbon), with small quantities of other bodies, of which the chief are sulphur, phosphorus, and lime. But these elements are not arranged according to their ordinary affinities. Exposed to the air, albumen decays, the carbon unites with oxygen to form carbonic acid, the hydrogen unites with oxygen

and forms water, and with nitrogen to form ammonia. Similarly, the sulphur and phosphorus select some other ingredients of the albumen, or of the atmosphere, to unite with them into simple compounds. In time the process is complete, and from being an organic substance, the albumen has wholly passed into a variety of *in*organic substances. In doing so it has given out a certain amount of force, chiefly in the form of heat; and this force, if the albumen had formed part of a muscle or a nerve, would have been operative in the function of the same. Now, it is on account of this force which is in the albumen, and is not in the inorganic substances which are formed by its decay, that it is called *organic*." Now, "this albumen," says Dr. Carpenter, in his "Animal Physiology," "is the very basis of all animal structures, and the great source from which they are formed and nourished, and appears to perform in the animal economy a part precisely corresponding to that of gum in the vegetable." But it may exist in two states,—the soluble and the insoluble. In the egg and in blood it is associated with one and a half per cent. of soda; and it is the presence of a small quantity of alkali which is supposed to render it soluble; for on the abstraction of this, or on neutralizing it with an acid, the albumen is precipitated in its insoluble form. Hence it is easy to foresee how, at the point where chemical decomposition may be going on in its solution,

and neutral crystals forming as one of its results, this albumen, precipitated in its insoluble form, may become entangled in their formation, and so constitute what is termed the "*basement membrane*" of the substance.

The first change which can be traced in albumen is in its assuming a tendency to *spontaneous* coagulation when withdrawn from the living body, and in the traces of organization which are presented in the coagulum or clot.

The part separated is *fibrin*, from its assuming the appearance of fibres. "But," says Dr. Carpenter, "it appears that fibrin may be consolidated, not merely into fibres, but also into very thin layers of membrane, in which no traces of *structure* can be perceived. Such a membrane is found covering every free surface of the body, both external and internal. *It forms the outer layer of the true skin, lying between it and the scarf skin.*" "It may be obtained, too, from any shell, by dissolving away the mineral portion with an acid. Such a combination of membrane and mineral matter forms the whole thickness of many shells, and the inner layer of all." "This membrane is termed the *basement* or *primary* membrane, and, like the elementary membrane in plants, it is remarkable for the readiness with which it is permeated by fluid, though no visible pores can be seen in it."

This same membrane, which so forms the whole

thickness of many shells, also forms the basis of dentine. Human dentine contains about from twenty to twenty-eight parts in every hundred of it, and the enamel about three parts in a hundred. Specimens from each—that is, from dentine, bone, and shell—are placed side by side on one of the cards before you. Now, as all simple membranes and fibrous tissues are concerned in actions purely mechanical, and are amongst the lowest forms of animal tissue, this membrane, having no special vital *action*, being merely a mechanical agent in the fabric of the tooth, can be regarded as vital only in virtue of its being an *organic* or *vital* substance.

Hitherto we have confined our remarks to the dentine exclusively as an organic body. We have now to consider it in its relation to the tooth as a vitalized organization.

That the pulp of a tooth is a living body, capable of performing vital actions, is a fact not to be disputed; and that it must also have been placed there for some special advantage to the tooth, during its active existence, will scarcely admit of a doubt. Yet, when it has been lost, a tooth which has had its place supplied by a successful stopping is calculated to continue quite as long in this state as with the pulp remaining. Therefore the pulp cannot be said to be essential to the tooth's existence, nor can it be said that a tooth will be more effective *with* than *without* it; for if

solid, it would be equally useful so far as the mere mechanical action is concerned. Hence, were the teeth intended to be mere mechanical agents in the mouth, like the particles of diamond in the stone-cutter's wheel, there would have been no need for this beautiful fabric of living structure in their interior; therefore it must have some other function than that of nutriment to the dentine; and what so likely as that of endowing the part with sensation? Are not we conscious of the slightest touch upon these organs? And whence, then, this delicacy of perception but through the fine branches of the nerve ramifying in their interior? Seeing that it is not needed for the tooth's existence, nor capable of casting off any portion of its dead or dying exterior shell, it is but a just conclusion that its main purport should be for providing a certain amount of feeling in the crowns of the teeth.

It is said that the teeth are "*dermal appendages.*" They are more than this: they are a portion of the cutaneous system itself. In the skin we have, first, the epidermis or cuticle, immediately beneath this a layer of basement membrane, and below that the cutis vera, or true skin. This is composed mainly of white fibrous tissue, interspersed largely with blood-vessels and nerves. Its surface is elevated in many parts into papillæ and ridges. These papillæ are specially organized for delicacy of feeling, and abound

most in those parts in which the greatest acuteness of sensation resides.

In the human tooth we have precisely the same arrangement of parts, though considerably modified to suit the altered requirements. The pulp represents the cutis vera, or sensitive skin, and has its full share of nerves and blood-vessels. The dentinal fibrils of Tomes form an equivalent for the papillæ of the cutis. The basement membrane, which in the skin is aided by the mucous layer of the epidermis in forming a layer of sufficient thickness to shield their delicate extremities and support them against the effects of too much pressure, in the tooth forms the whole, or nearly so, of this protecting shield. It is further aided in this respect by the additional hardness gained from its intermixture with an earthy basis. In the skin we have the outermost layer of all forming a tough and elastic substance, capable of yielding to every movement of the subjacent muscles and joints, and "appears," says Dr. Carpenter, "solely designed for the protection of the true skin from mechanical injury and the pain occasioned by the slightest abrasion, and from the irritating influence of exposure to air, and of changes of temperature; we perceive the value of this protection when it has been accidentally destroyed." In the tooth, on its crown the enamel, and on the fangs the cementum, take the place of this horny layer of epidermis upon

the skin. But as an elastic and yielding surface upon an *in*elastic and *un*yielding surface of dentine would be out of place, elasticity has been superseded by extreme density; and hence we have one of the hardest of all known animal structures, and one well suited to its office. On splitting off a portion of this from a living tooth, or on drilling through it, the exquisite sensitiveness of the under-lying dentine, as in removing the covering from the sensitive skin, is equally a reminder of the value of the enamel as a protective covering.

The persistent capsule of Nasmyth would seem to be neither more nor less than a layer of basement membrane formed between the secreting surface and the crystals of enamel to which it is adherent, and in some degree continuous with and identical with the inner layer of membrane which can be separated by means of an acid from the interior of all shells; and whether this be capsule, or any membrane concerned in the production of the enamel, is best answered by a reference to the mollusca, and a suggestion as to whether, in that case, the membrane forms part of the mantle or other portion of the animal by whose instrumentality it is formed. The answer would be decidedly not, and I can see no reason to doubt the identity of the other as a like production.

Respecting the office of the dentinal fibrils, a paper in the "Philosophical Transactions" for 1850,

"On the structure of the *Dental Tissues* of the Order Rodentia," by Mr. Tomes, will afford a convincing proof that there is method and order in the course of the dentinal tubes; and there is little reason to doubt but that in those instances in which these are carried into the enamel, it is to bring the sensitive ends of the dentinal papillæ by which the tubes are filled nearer the surface, so as to obtain more acuteness of feeling, and at the same time secure sufficient strength in the enamel for its purpose of resistance. That such is the intention and use of the tubes and their contents is further borne out by the fact that where the incisors are formed *upon*, but not *around*, the pulp, and increase in length by age, protruding from the jaws so as to partake more of the nature of weapons than teeth, we see the tubes and their contents in the exposed part dispensed with and supplanted by solid material; thus doing away with the power of feeling, which would, under such circumstances, be in some measure detrimental to them as implements of warfare.

The extension of the fibrils into the enamel is a still nearer approach to the arrangement of their prototypes; in the skin the papillæ pass up into the lower half of the outer layer of epidermis in the same manner, and thus show a correspondence of contrivance equally, it must be supposed, for a similar purpose.

In the early stage of the tooth, its first indication of growth "is a slight projection of the mucous membrane, which soon increases in size, and forms a papilla. This papilla is the primary condition of the tooth-pulp." Hence, as the mucous membrane is identical in structure with the external skin, and the pulp of the tooth a portion of it, we see at once, in its origin, its identity of parts as the framework of the subsequent structure, where each one has been so altered and adapted to a specific end, as to gain for the whole a peculiar and suitable condition for its purpose. Nor is this change, by alteration of circumstance in the condition of the components of the tooth, without its parallel; for we have an analogous case in the skin becoming mucous membrane and mucous membrane taking on the condition of the external skin when transposed from the position of the one to that of the other.

Such, then, being the principal features of the several elementary portions of the tooth, we are now prepared to consider that abnormal condition of the dentine known as decay, and to investigate the various actions and conditions of matter leading to its production.

In the composition of dentine we have about one fourth consisting of an *organic* substance, and as all organic matter is held together, as such, in a peculiar combination known as "*vital*," which,

when overpowered by chemical affinity, gives rise to inorganic resultants, that the organic basis of dentine should be subservient to the general law is but a just inference; therefore, if we apply to the dentine the same principles of change which are known to take place in other organic bodies, we certainly should not be other than justified in expecting corresponding results.

This chemical transference of elements is best illustrated by ordinary combustion with heat. Thus, if a match or a piece of paper be set on fire, it will go on burning and leave a blackened ash as a residuum. The ligneous fibre of which both these are composed is an organic substance; it consists of hydrogen, oxygen, and carbon, the two former gases, and the latter a solid. The two gases are in the proportion to form water, but are here united with carbon in a manner which defies the synthetic powers of the chemist to imitate. Man may even make organic bodies. He may effect numerous changes and combinations in organic elements, and produce various forms and substances of different aspects and properties; but it is the Creator alone who can make that organic material and endow it with that condition which is indispensable for its increase and extension. In the destruction of this material by the process of burning, the elevation of temperature destroys the attraction of the vital force which keeps together the combination, and chemical

affinity then causes the separation of its elements, inducing the two gases to combine and form water, while the greater portion of the carbon is left as ordinary charcoal. But heat is not the only agent capable of effecting this change. Concentrated sulphuric acid has so great an affinity for water that it will deprive an organic body of the elements of this compound, and become discoloured by the resulting charcoal. Other substances will have a similar effect. It occurs also as a natural process. In rotting wood we have an instance of it. It is, in fact, one of the ordinary modes by which once living matter returns to the inorganic world.

If we burn a feather or a piece of animal membrane, we have, in addition, a disagreeable odour, arising from the sulphur and phosphorus in combination with its nitrogenous compounds, but in other respects the change is precisely the same; and as discoloration is one of the natural consequences of dead organic matter, whether vegetable or animal, undergoing its ordinary course of conversion in a comparatively dry state, we may reasonably look for discoloration in decaying dentine. Such, indeed, is commonly the case, and is often the first and only sign by which we know that the death of the part has taken place.

Whenever this discoloration occurs upon the crown of a tooth, and has taken place slowly, a

section of the part invariably shows its direction to be toward the central cavity.

The texture, too, for some time retains its original firmness. It is one of those phases of decay which it is wholly impossible to explain by the external action of an acid. In the three specimens,* marked A, B, and C, of No. 1 card, we have a notch at the neck of each. In all these a discoloured spot will be seen in the centre of the notch. Now, had these spots been produced by the aid of an acid, the surface, as seen by reflection, must have shown a roughened outline instead of the high polish it now bears. It is only by the organic death and decomposition of the membranous part of the dentine that it can be satisfactorily accounted for.

Mr. Tomes defines decay as "*the death and subsequent progressive decomposition of a part or the whole of a tooth.*"

Hunter remarks that "the simple death of the part would produce but little effect, as we find the teeth are not subject to putrefaction after death; and therefore," says this great physiologist, "I am apt to suspect that during life there is some operation going on which produces a change in the diseased part." The change here alluded to *does* take place, and may be thus explained.

* The specimens here and subsequently referred to are placed in the Society's Museum.

In Fownes' "Manual of Elementary Chemistry" it is stated that "Azotized albuminous substances, which, in a more advanced state of putrefactive change, act as alcohol ferments, often possess, at an earlier period of decay, the property of inducing an acid fermentation in sugar, the consequence of which is the conversion of that substance into *lactic acid;*" and, again, that "*moist animal membranes in a slightly decaying condition often act energetically in developing lactic acid.*"

Now, as so large a proportion of our food contains sugar, or substances capable of being converted into it, and "*the moist animal membrane in a slightly decaying condition*" being provided by the dead portion of dentine, we have thus brought together under the most favourable circumstances the elements requisite for the production of an acid. Respecting this compound, Professor Brande says, "lactic acid has a considerable solvent power over phosphate of lime;" therefore we have not only the production of an acid, but the formation of one capable of dissolving out the earthy constituents of the dentine. But there is here one condition requiring especial notice. Moisture is so essential to chemical action, that few chemical changes can occur in its absence; thus, while the dead membrane can remain comparatively dry, it is able to resist this change; but so soon as it becomes charged with additional moisture, the change suspected by Hunter will speedily follow.

There is a specimen before you which fully exemplifies this power of resisting the change when kept dry. It is a molar tooth stopped by Woodcock upwards of twenty years previously to its coming into my possession. The discoloured dentine between the stopping and the central cavity being the remaining portion of the radial strip of which the plug forms the base of the cone, most unquestionably formed part of the original mischief, although possibly it might be but little discoloured at the time. Through having been kept dry, it has been prevented from undergoing this change. It also illustrates the fact that this stage of decay is only progressive toward the central cavity, and that it is not until the acid is produced that a cavity is formed and becomes enlarged in every direction. The acid, being generated within the moist membrane containing the crystalline matter, is thus brought into immediate proximity with the part to be dissolved, and the decalcification of the softened stratum rapidly succeeds. Mr. Tomes says, "It might be supposed that similar results would be produced from decalcifying a tooth by the aid of a dilute mineral acid; such, however, has not been the case in experiments instituted with the view of determining the point. Indeed," says the author of the manual, "I know of no artificial means whereby the appearances which have been described can be as fully brought out as by the progress of

disease;" and further, "The connecting material is usually the first, and the walls of the tubes the last, to become disintegrated." We have in these facts a corroborative proof that the acid solvent must be in some way differently circumstanced to an ordinary external solvent, and, by the latter fact, a proof that it cannot be provided through the dentinal tubes; hence it is obvious that it must be through some change in the intertubular substance that the solvent is enabled to find access; and in accounting for the presence of the acid in the present manner, facts and theory fully coincide.

The intensity of colour in decaying dentine depends wholly upon the length of time occupied in its production. Hence, when the combustion has had time to be completed, a charcoal blackness may result, while, if acidity commence before this stage has been attained, any shade of brown may be produced. When acidity commences at the very outset, which it may do from mechanical injury to the surface, the disrupted part may remain almost colourless; and when the texture has been broken up, and insufficient acid generated to dissolve the whole of the lime so displaced, we have that state of decay known as "chalky" or "friable."

The uniformly acid state of decalcified dentine when first removed from the tooth, together with the equally acid condition of the accu-

mulated food beneath the plates and frames of artificial dentures, in the absence of a knowledge of the previously mentioned facts in chemical science, would naturally be attributed to the decaying of the food itself, and consequently lead to the supposition that extra cleanliness might *prevent decay*. The real source of the acid, however, in this accumulated food, may be traced to a similar cause to that in the dentine.

The epithelium of the mucous membrane of the mouth, like the epidermis of the skin, is constantly shedding its outer layer of worn-out or used-up cells, and the membrane of these cells is also liable to the same change as the membrane of the dentine. A trace of the effects of acid so generated may often be seen on the approximal sides and lingual surfaces of aged incisors. But we have another and far more marked illustration of its effects. We often see the necks and upper edge of the enamel much corroded in the upper incisors. The epithelial cells, rubbed off from the gum and inner surface of the upper lip, are wiped by the action of the lip into the groove formed at the junction of the gum with the tooth, and there being allowed to remain, soon generate sufficient acid to destroy the surface and texture of the enamel. But everything connected with this is so thoroughly different, that it is scarcely possible for it to be mistaken for ordinary decay. The roughened surface, the green tinge of the dis-

coloration, and its superficial and spreading character, all indicate the action of an external agent as opposed to the usual signs of decay.

From the existence of this source of an acid menstruum, the question which will now arise is, how we are to determine the limits of its action; and whether the decay occurring at the necks of the teeth may not arise from the same cause. A close and careful attention to the facts will, I think, sufficiently guide us in this discrimination. A stained spot and the absence of external roughness are sure indications against it, for discoloration under the action of an acid is always, *not* as in ordinary decay, its *antecedent*, but invariably a *subsequent* result. The large patches of decay occurring at the necks and on the exposed fangs of denuded teeth are mostly attributed to this source, but unjustly so. We must not overlook the fact that in this case the dentine is not in its normal state. It has lost its protective covering. It was never intended for exposure, even to so much as the moisture of the mouth. And it is not impossible that the latter may prove as much a source of irritation, and as much an enemy, as the acid. But we have here No. 2 card—a specimen which speaks volumes upon the subject, affording a far more substantial proof of *non-external acid action* than anything which can be said on the subject. It is a lower incisor largely coated with tartar. On one side (*A*), beneath the

upper edge of the tartar, appears the edge of a stained spot, upon which the tartar yet remains.

On the other side (*B*) is a large shallow cavity, bearing the most palpable evidence of strong acid action both within and around it, while the subjacent tartar has been dissolved off, through the acid fluid running down on to it. *C* and *D* are further illustrations of this.

From this contrast it is unmistakable that, had *exterior* acid existed and been the exciting agent, the one side would *not* have been *still covered over with tartar*, while the other bore such strong traces of its action.

The whole appearance of the tooth is that of age. The covered-up side bears the peculiar mark of a dead and decaying animal substance prior to the formation of the acid solvent. The other side as forcibly illustrates, by the course it has taken, the source of the acid; and its being produced at the cavity consequently implies the aid of the dead membrane in its production.

The decay of all animal substances, when used for artificial dentures, has always been instanced as a strong proof of decay being produced by the fluids of the mouth, because when covered over with tartar they usually remain intact. But as it is equally so wherever friction has kept the part polished, the inference is not altogether correct. The fact is, that, under every circumstance, these substances will be found to conform to the same

laws, in every respect, as pertain to the human dentine in its natural state. The material is an organic substance. It is subject to the same kind of death as all vital bodies. Its membrane, under similar circumstances, develops lactic acid, which leads to the same results in the one as in the other. The same mechanical states affect the durability of both. Soft substances are rapidly softened and destroyed, while hard ones resist softening for a longer period. Soft bodies generate acid speedily, while the harder ones show the tinge of departing life. This is well illustrated by the walrus and hippopotamus ivory, which vary very much in density: some decaying at once, while others last for many years, with little or no signs of decay; thus proving the fact that the denser the dentine the longer it will last in the mouth.

It has been supposed that a living body possesses some *vital principle* which enables it to resist, in some measure, external chemical action, and the solution of the stomach after death into holes by the gastric juice has been instanced in proof of the power of a living organ to defy such action during its lifetime; but this immunity is more justly to be assigned to the protecting influence of the secreted mucus, which ceases to be produced so soon as life has become extinct.

"The existence of a distinct vital *principle* was formerly believed in by the early physiologists.

The idea was, that if this principle quitted the body, the result was death; that it animated, directed, formed the body, preserved it from the effects of chemical action, and on quitting it, left it a prey to this destructive action, which was manifested by its dissolution." The belief in such a *principle* has long since been discarded, and that which now takes its place is being explained as consisting of a vital *force*.

It is supposed that this vital force, which makes albumen out of elements having a tendency to form other combinations, is given out when the albumen dies, and manifests itself in some way or other—that is, either by producing future growths or some one or more of the physical forces.

Professor Grove, in his "Correlation of the Physical Forces," has endeavoured to show that the various affections of matter which constitute the main objects of experimental physics, viz., heat, light, electricity, magnetism, chemical affinity, and motion, are all correlative, or have a reciprocal dependence. That neither, taken abstractedly, can be said to be the essential or the proximate cause of the others, but that either may, as a force, produce the others. Thus heat may, mediately or immediately, produce electricity, electricity may produce heat; and so of the rest, each emerging itself as the force it produces becomes developed; and that the same must hold good of the other forces, "*it being an irresistible*

inference that a force cannot originate otherwise than by generation from some antecedent force or forces." It is thus that all the forces developed in the animal system, such as heat, motion, electricity, chemical action, &c., are believed to spring from the vital force. Dr. Carpenter, enlarging upon the idea of Professor Grove, endeavours to show "that *the same relation* (in whatever way defined) exists among the several vital forces, whose operations may be traced in living bodies, as exists among the physical; and that the vital and physical forces are themselves connected by a similar relationship." Thus, whenever any force becomes manifested, it is at the expense of, or by the death of, some particular part of the organism. And whenever any particular force is required of any particular part or organ, it is so constructed as to be able to give out this force, and have its parts reconstructed at the same time, so as to keep up the supply. Hence, as all parts are so constructed relatively to the amount of vital action they are called upon to perform, so, consequently, is the amount of vital activity of any part proportioned to its construction.

"We have," says Dr. Carpenter, "evidence in the phenomena of nervous action, that the production of nerve-force, like the development of muscular power, involves the degeneration and death of a certain amount of the tissue which serves as its instrument; so that we are furnished

by this fact with an additional reason for the belief that nervous agency is to be regarded as but a peculiar *modus operandi* of the same force as that which is elsewhere operative in cell-development." Hence, as all sensation is the manifestation of nerve force, and the latter, produced by the death of cell-nuclei at the peripheral extremities of the nerve, and all nerves requiring a supply of oxygenated blood for their maintenance, we see in the pulp of the tooth only a necessary organization for the power of feeling, and which is the only normal function that can be recognized as its fulfilling; for that of furnishing new solid matter in the production of secondary dentine, and the consequent change in its own form, must be acknowledged as more strictly pertaining to its *ab*normal condition, and to be a step taken wholly with a view to screen and protect itself from the noxious influence of contiguous irritants.

In considering this subject we have to keep in view the existence of three separate forms of matter.

1st, an organic material; 2ndly, an organic body; and 3rdly, an organized condition or vitalized organization.

1st, an organic material, as gum or albumen, out of which organic bodies are made.

2ndly, an organic body, when the organic material assumes a definite shape, but possesses none other than the ordinary physical properties per-

taining to matter generally, and which may be formed either *in* or *out of* the system.

3rdly, a vitalized organization, or an organized condition, when it forms part or the whole of any body having power of increase, or of performing vital actions.

Thus, in the tooth we have first, in the enamel and dentine, an organic body; secondly, in the pulp, a vitalized organization; in the tooth collectively, a vitalized organization, with an organic body as an external covering.

In the preceding sketch the physical arrangements, together with the physiology of the tooth, have been the main objects of attention. The pathology of the organ leads to a consideration of the relative influence of the pulp upon the dentine, and *vice versâ;* or to what extent the decay of the one, and the abnormal condition of the other, may be supposed to be able to affect its companion.

The principal physical conditions leading to the decay of the dentine, are—

1st, A defective formation, or an imperfect condition of the enamel covering.

2ndly, Mechanical injury to the enamel and the outer stratum of dentine immediately beneath it.

In a former paper on "Lateral Pressure," it was stated that, under certain mechanical conditions of the mouth with regard to its shape, the growing tooth, while within the alveolus, was not

subject to pressure from the adjoining organs. That in consequence of this, the enamel would be thickly deposited at its centres of commencement, and not be so spread as to unite sufficiently where the edges of the several plates meet. Now, wherever this want of union occurs we see, especially in the bicuspids and molars, either a fine dark line or a pit or fissure, in which decay, sooner or later, is almost certain to occur. And as a strong corroborative proof of the source of this defect, it may be stated, that in mouths of an opposite form, where the alveolar ridge has been under the influence of pressure during the same period, the teeth will invariably be found to be free from such imperfections.

That decay may be produced by mechanical injury is, unfortunately, too well known to admit of a doubt. The effect of undue pressure of one tooth against another, and the friction of a band upon the neck of a tooth, are, unhappily, the too frequent sources of regret to be unheeded.

The mechanical disintegration of the enamel crystals is the first stage in the proceeding, or, if at the neck of the tooth, a slight breaking up of the surface of the dentine. The absorption of moisture by the injured membrane is the next stage. The development of the acid then follows, and is rapidly succeeded in regular order by the usual symptoms. In the previous paper on lateral pressure, it was stated that decay might be pro-

duced through the injury inflicted by one tooth upon another in its passage through the gums. The injury to the one pressed against, as well as the one pressing, is accounted for in supposing that the texture is in some degree bruised or broken up, a slight molecular disturbance in the arrangement of the ultimate particles occurring, so as to lead subsequently to its future decay, through being rendered incapable of resisting the absorption of moisture. That this is true, is rendered extremely probable by the fact, that decay under such circumstances extends fully down to, or even beneath, the edge of the gum, while the one causing the mischief almost invariably has a circumscribed cavity on the most prominent face of the enamel which came in contact with its opponent.

In the case of defective enamel, the course taken is different to this. The first indication of change is the discoloration arising from the organic death of the membrane. To what extent, or whether if at all, this may be liable to be brought about by the morbid condition of the pulp, must be judged by the ordinary mode of procedure, as it affects the corresponding tissues. That the pulp is liable to inflammatory stasis we can have ocular proof at almost any moment, on the removal of an aching tooth.

Mr. Lister's experiments, recorded in the "Philosophical Transactions" for 1858, go to determine

that whenever inflammatory congestion, or, in other words, that disturbance of the circulation which is truly characteristic of inflammation, exists in any degree, the tissues of the affected part have, to a proportionate extent, a temporary impairment of functional activity or vital energy, and that stagnation of the blood-corpuscles is only a secondary effect, consequent upon some previous change in the tissue and state of the blood; and consequently, it would be unfair to assert of the suspected tissue, that where there are no red corpuscles there could be no vitiated condition of the fluid part, or no altered state of the membrane, which would lead to their accumulation or "stasis," were they to be present. And therefore, although we have no red corpuscles in the dentinal fibrillæ, it is more than probable that the liquor sanguinis, without them, is present. And that *it*, as well as the tissues for its circulation, are liable to the same change as in ordinary inflammation leads to the inflammatory stasis. Mr. Paget, in his lectures on surgical pathology, says, "When we see such gradual transitions from the normal process of nutrition to the disease of inflammation, that we cannot draw a definition between them, we may be sure that the main laws of physiology are the laws alike of the disease and the healthy process." Therefore, as we have incontestable proof of the presence of nerve-matter in the fibrillæ, and as we know that this nerve-

matter requires the presence of a nutritive fluid—indeed, its presence is evidenced in the production of new dentine at the extremities of the dentinal tubes—we are fully justified when we infer that the abnormal condition of the fibrillæ is as near an approach to the character of ordinary inflammation as the nature of the nutritive process itself, as carried on in the dentinal fibrillæ, is to that of ordinary nutrition. But there are here two specimens, having in each a very decided patch of red matter, intermediate with the central cavity and the peripheral surface, and no apparent connection with either; which are strongly indicative of the red matter of the corpuscles, if not the corpuscles themselves, as in inflammation of the cornea, having been carried or generated there by inflammation, quite within the substance of the dentine.

In the production of inflammation by the application of external irritants to the skin, these have to act through the outer layers,—the epidermis and basement membrane,—to get at the tissues of the capillaries; and as the tissues undergo temporary impairment of vital energy, the epidermis being often killed and separated, we have no reason to believe but that the membrane of the tooth should be equally susceptible to the influence of external irritants; and such being the case, the exposure of the peripheral surface of the dentine where the enamel is defective would lead

to similar results. That some degree of irritation does result to the dentinal fibrillæ through imperfections leading to decay, is fully established by the production of new dentine,—the reparative zones of Tomes.

In this, however, we see but the fulfilment of an ordinary law.

One of the common results of inflammation is the production of "inflammatory lymph," which has the characteristic property of "spontaneously" organizing itself, and proceeding by development to the construction of tissues like the natural structures of the body. "In inflammation of bone, the lymph usually ossifies; and the fact is explained by believing that the material formed in the inflammation of each part partakes from the first in the properties of the natural products of that part,—in properties which we know often determine the mode of formation independently of any assimilative force." Therefore, if we interpret the facts of the formation of secondary dentine, as it is termed, according to this view, we shall arrive at a somewhat clearer understanding of much that is otherwise confusing and obscure.

There are here (No. 4 card) the crowns of two molars, which have nodules of secondary dentine formed within the pulp-cavity: in one (*C*) the small botryoidal mass remains adherent to the roof of the cavity under its masticating surface; in the other (*B*) it is imbedded in the upper

surface of the pulp. In both these, on their masticating surfaces, are imperfections in the enamel, with signs of commencing decay. Now, it is a very common circumstance to have one's patients complaining of a degree of uneasiness and uncomfortable feeling, amounting sometimes even to severe pain, in teeth which are not more decayed than these; and I have, on repeated occasions, found such nodules of dentine, sometimes to a large size, implanted in the substance of the pulp, but invariably immediately at the point nearest to the source of irritation. As a layer of new substance attached to the original dentine, we find it of common occurrence, and very often forming a ring or tube, as in *E*, narrowing the canal for the reception of the neck of the pulp. "As a general rule, the less the degree of inflammation, the more is the product like that naturally formed in or by the part, till we descend to the border, at which inflammation merges into an exaggerated normal process of secretion." This is fully borne out in the production of new dentine. When the inflammation is but very slight, we have the reparative zones close to the peripheral surface; but when the production of an acid has commenced, we find the irritation leading to a more profuse production of matter, and often as unattached globules. It has been supposed that this calcification takes place most readily under an amalgam stopping, and which is possibly true,

and owing to the amount of irritation caused; but it is very probable that means may yet be found of bringing it somewhat under control, and thus enable us to effect it with some degree of certainty.

That the pulp, then, is subject to irritation through agents affecting the dentine, or that it can be affected by actions which also tend to the death of the membranous part of the dentine, is fully established by the preceding facts; but to what extent the morbid condition of the pulp from constitutional causes can affect the dentine, it is less easy to define. That the ordinary death of dentine is not produced from internal causes is self-evident from the conical strip of discoloration often, or mostly, *not* reaching to the *centre*. But that a general disturbance of the system may affect the dentine is, I think, implied in the circumstance of the teeth which were previously sound and healthy often becoming rapidly decayed after an attack of fever or some constitutional change. Under such circumstances we find the hair coming off and the skin peeling; therefore there must have been some interference with the cutaneous system generally. And what more likely than that the teeth should have shared in the change? One of the main elements of health in every organ of the system is that of its having its right proportion of moisture. Deficiency or excess leads to disease or disorder. Its supply

being mainly through the vessels of nutrition, the extreme permeability of the membranes and walls of the tubes facilitates its ready access to every part of the system; and being preserved constantly in motion while in healthy action, its stagnation is prevented, and every part is kept regularly supplied with its required quota. One of the peculiar features of basement membrane is its ready permeability to fluids; therefore, in the case of deficiency or excess, it is liable to suffer; and thus if at one time there might be a check in the supply, or, perhaps, even a drain upon it, the abstraction of a portion of its moisture must necessarily affect the condition of the membrane. Hence, when reaction commences, the free return of the moisture, finding the membrane with its vital force weakened, or in a condition to be rendered so by an undue supply, through its mechanical condition having been altered by the collapse consequent upon the check, will tend to the production of its death and the subsequent changes usually attendant upon softened dentine. The principal fact favouring this view is, that the decay occurring under the preceding circumstances almost invariably progresses with great rapidity, and shows a softened state of the dentine to nearly the full extent of the portion remaining. It is often believed that a *soft* state of the dentine indicates a deficiency of the earthy matter. Dr. Stark, on this point, says, "The hardness of

bone does not at all depend upon the presence of an unusually large proportion of earthy matter, nor does their increased flexibility and transparency indicate a deficiency of the mineral ingredients; for transparent, readily cut bones of fish contain the same amount of earthy matter, in proportion to their gelatinous bases, as do the dense ivory-like leg-bones of deer and sheep. The difference appears to depend upon the molecular arrangement of the ultimate particles, and especially, it seems likely, upon the relative amount of water which the bones contain." Dr. Carpenter says:—"The perfect elaboration of the albuminous constituent of the serum has been shown to be requisite to prevent it from copiously transuding the membranous walls of the vessels which it traverses;" and again, "the transudation of the watery portion of the blood is much increased by any impediment to its flow through the vessels, and also by any cause that produces a diminished resistance in their walls." We have, then, in the dentine, a texture peculiarly adapted to imbibe a considerable amount of moisture, and pathological changes possibly taking place in the pulp capable of furnishing an abundant and abnormal supply of fluid with which it may become "dropsied." Therefore, that the morbid state of the pulp does affect the healthiness and durability of the dentine, I think may be reasonably believed; and that it may lead to the death and rapidly

developed acid tending to the speedy destroyal of the whole crown of the tooth.

In the early stage of decay, when stopping is about to be had recourse to, the removal of the dead dentine is but fulfilling the end the pulp would do for itself, had it the power of absorption and exfoliation. As it is, instead of removing the dead part, it attempts a new barrier between itself and the encumbrance; and were it *not* possible for acidity to supervene, there is every reason to suppose such an attempt would prove successful. These stoppings in incipient decay are notoriously the most lasting. The reason *why* they should be so is obvious; the removal of the *dead* membrane, and its place occupied by a *non-absorbent*, *non-decaying* substance, is all that is needed to secure success. But when acidity has once commenced, the neutralization of the acid in the remaining portion of the dentine is essential. This, however, is rarely or never done. Indeed, I believe it has never before been suspected that the prepared cavity in most cases still bears strong traces of an acid. That it does so is proved by the rapid action upon a metallic paste stopping. Most of the metallic oxides are soluble in lactic acid, and photography has taught us that many of these are darkened by the action of light, &c. Therefore, neutralizing the acidity in the cavity prior to the use of an amalgam *ought* to prevent its becoming discoloured. This

I have long since proved to be the fact, and that with *proper care* the mercurial stoppings or amalgams may be used even to the front teeth, as well as in those of delicate texture, without the slightest trace of discoloration. After clearing the cavity of so much of the softened dentine as may be needful, a small portion of the paste, composed of chalk and magnesia, is placed in the cavity, with as much moisture as will suffice to form a creamy consistence. The cavity is then filled lightly with lint, and this is suffered to remain until the stopping material is ready. Of course, the state of the tooth must regulate the length of time necessary to effect its completion, but in ordinary cases five or ten minutes will be sufficient. The cavity must be well syringed out with hot water several times previous to being dried finally for the stopping. Under any circumstances, I almost invariably have recourse to an alkali previous to plugging, and I rarely or never find discoloration follow when this has been carefully attended to.

In the preceding remarks, the various physical, physiological, and pathological facts, where practicable, have been given in the words of the several authors referred to, and where otherwise, with a full acknowledgment of their source; thus leaving myself responsible only for the deductions which have been made from them.

What I have sought to establish is this: That

the human teeth are *not* merely *dermal appendages*, but a portion of the cutaneous system, all parts being so modified as to be peculiarly adapted to the altered circumstances in which they are placed, and the special duty required of them.

That *decay* is the natural death of the organic basis, or basement membrane, of the dentine, and consequently a *vital phenomenon*. And that, subsequently, the presence of moisture in the dead membrane leads to the development of *lactic acid*, which is the cause of its progressive tendency, and that a more correct definition, instead of the term "*caries*," will be "*vital decay*" so long as it retains its primary character, and "*chemical destruction*" when acidification has commenced.

That artificial dentures of organic materials are subject to the same laws, and owe their destruction to precisely the same cause as do teeth in their sockets.

That the epithelial cells, from the membrane of the gums, &c., also lead to the development of lactic acid, and are the cause of that destruction of the enamel so often met with in the upper front teeth. And that the formation of new dentine, or "calcification," as it is termed, is the result of the common law by which inflammatory lymph leads to the production of new tissue, and is consequent upon irritation caused by external agents acting upon the pulp and its dentinal fibrils. And to point out that the proper neutrali-

zation of the acid remaining in a decayed tooth, *prior to filling*, will not only render the stopping far more likely to prove successful, but will wholly prevent the dark stain hitherto considered one of the unavoidable accompaniments of amalgams, and thus render this class of stoppings infinitely more valuable to the profession.

GENERAL MONTHLY MEETING.

Monday, April 1, 1861.

W. M. BIGG, Esq., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Mr. George Laurie .....26, Mortimer Street.
Mr. Samuel Parker .....Colmore Row, Birmingham.
Dr. Dunning .....New York, America (Corresponding).

The following Donations were made to the Society:—

Mr. John H. Parkinson, Sen.—Fossil Tooth of Mastodon; Fossil Tooth of a Shark found at Alexandria, in Egypt; a Fossil tooth of the Ichthyosaurus; the Canine Tooth of a Tiger.

Dr. S. S. White, of Philadelphia.—Vol. i. of "Dental Cosmos;" "Dental Anomalies," vol. i.; two copies of coloured plates of Fifth Pair of Nerves, with diagrams illustrative of the Microscopic Anatomy of the Teeth; two copies of Key to the same.

Mr. Truman.—Romberg on "Diseases of the Nervous System," 2 vols.; F. Oesterlen's "Medical Logic," 1 vol.; T. Sydenham, the Works of, and Translation by Dr. Greenhill, 3 vols.; Schwann and Schlerden's "Microscopical Researches into Accordance in the Structure and Growth of Animals and Plants," 1 vol.; Unzer and Prochaska "On the Nervous System," 1 vol.; Wedl's "Pathological Histology," 1 vol.; Harvey, M.D., Works of, 1 vol.; Hasse's "Pathological Anatomy," 1 vol.; "On Small-pox and Measles," 1 vol.; Churchill, "Diseases of Women;" Feuchtersleben, "Medical Psychology;" Dupuytren "On Diseases and Injuries of Bones," 1 vol.; "On Lesions of Vascular Systems," 1 vol.; Hunter's "Gravid Uterus;" "Memoirs of the Academy of Surgery;" "The Genuine Works of Hippocrates," 2 vols.; Kölliker's "Manual of Human Histology," 2 vols.; "Annals of Influenza;" W. Hewson's Works, edited, with an Introduction and Notes,

by G. Gulliver, F.R.S.; Rokitansky's "Pathological Anatomy," 4 vols.; Küchenmeister's "Manual of Parasites," 2 vols.; Von Siebold "On Worms."

Mr. COLEMAN read a paper

On the Nature of Dental Caries.

Mr. PRESIDENT and GENTLEMEN,—It may appear a bold step to introduce any new theory which proposes to explain more satisfactorily the nature of a disease which, from its very frequency, must have attracted considerable attention, and which has, almost of itself, called into existence the profession of which we are members. But it must appear a still bolder step to advance views which differ considerably from those which have hitherto been adopted by men of the highest reputation. It may be supposed that no individual would undertake so great a responsibility unless his ideas were the result of long observation, or unless they explained more satisfactorily a large number of phenomena, or unless they were confirmed by decisive experiments.

To the first of these conditions I can lay no claim. To the second I can only say that, to my mind, they explain more clearly the nature and process of caries of the teeth. To the third, however, I may observe that the experiments I have performed can, in my opinion, be explained by no other than the views I am about to advance.

I should have preferred waiting until I could

have laid claim to all of the above conditions, but that our attention cannot fail to be drawn in an unusual degree to this disease at the present time by a paper, remarkable for its comprehensiveness and originality, read at the last meeting of this Society by Mr. Bridgman.

All opinions which have been advanced upon the nature of caries of the teeth, which in any way recognize the action of agents external to those organs having an influence upon, or taking a part in, the changes they undergo, regard, I believe, the existence of an acid of some kind as essential; and consequently, looking no further for a cause, attention has been somewhat misdirected in investigating this subject.

Following out the researches of others, I confess I was somewhat surprised, in investigations carried out a few years ago, to find so little evidence of acid fluids in the mouths of many persons whose teeth presented the conditions of rapid decay. In the cavities themselves I found invariably an acid reaction; but occasionally an alkaline reaction was discovered in the saliva of those in whom, *à priori*, we should have anticipated strong acid reaction. The saliva is considered, I believe, as I have generally found it, to be usually neutral; but it is stated to vary under different conditions of the body. Thus, whilst any great demands are being made upon any of the acid secretions of the body—as, for

instance, in the stomach during digestion—the saliva is found to be alkaline ; whilst before a meal, when other and alkaline fluids have been more recently drawn upon, the saliva is found to possess an acid reaction. Be this as it may, this secretion, though of course ever in contact with the teeth, has never, to my mind, presented a sufficiently acid character, of itself, to account for the rapid disorganization we find going on in the teeth of certain individuals.

The acid found in the cavities of the teeth has been accounted for by the action of the decomposing tissues of these organs upon certain of the constituents of our food ; but I think it is more probably due to the formation of an acid phosphate of lime, furnished by the decomposition of the lime-salts of the dentine. Bone-earth, exposed to warmth and moisture—conditions favourable to decomposition—undergoes a kind of putrefactive fermentation, and furnishes the same acid phosphate of lime (the superphosphate) that is produced by the action of sulphuric acid on the same substance.

That it cannot be due to the decomposition of the decalcified dentine alone, is proved by the following experiment. From the cavities of a large number of recently removed teeth, the softened dentine, previously cleaned with dry cotton, was removed, and macerated in water. The reaction, which at first was nearly neutral,

soon became decidedly alkaline—a condition we should have anticipated in the decomposition of a nitrogenous compound.

If it arise from the action of the decomposing tissues on certain constituents of our food, producing lactic, butyric, or any other acids, we should scarcely find so strong evidence of its existence in those portions of the dentine which are hardly or at all softened, and which could, to so small an extent, only be permeated by the fluids of the mouth. This portion of the dentine I have found quite as acid in character as that removed from the more superficial portions of softened dentine in the same tooth.

In seeking for other than acid solvents capable of effecting a disintegration of the constituents contained in the teeth, we shall, probably, be aided in our investigations by observing some of the changes the food undergoes in its passage through the alimentary canal. The disintegration and solution which those substances undergo which enter the stomach as food, as well as some which occasionally find their way there by accident, cannot be traced to be due to any general solvent excreted from that organ; but partakes more of the nature of a process analogous to fermentation than to any other—a process of decay or change due to the action of certain bodies of weak chemical affinity, which readily undergo a state of molecular change, and induce

the same condition in bodies less prone to decomposition than themselves; the former are invariably nitrogenous compounds, which are the least stable of all compounds when of a complex composition. It is supposed that the molecular motion of these bodies is communicated to the particles of the more stable ones. Whether this be correct or no, we have the facts that decomposing gluten induces a change in grape sugar, converting it into dextrine, and then into alcohol and carbonic acid—compounds more simple in structure than those from which they were derived. Again, decomposing animal tissues, under certain conditions, will convert the same substance into lactic, butyric, and other analogous acids; and so also will the gastric and other fluids of the stomach, under the conditions of warmth, motion, and the presence of air, soften, disintegrate, and alter the chemical condition of substances used by us as food.

As the changes we wish to investigate take place in the mouth, it is to this, the first of the digestive cavities of the body, that our attention must be directed. Food introduced here is, we know, first subjected to the comminuting action of the teeth—organs mechanically well adapted for this office, and armed with an amount of sensitiveness to protect, no doubt, the stomach from the introduction of hard bodies that would injure its soft structures, as well as to afford a

knowledge of the degree of comminution that has been effected. During this operation, that of intimately mixing the food with the saliva likewise takes place.

The saliva, we learn from the researches of physiologists, effects chiefly the following objects: —1. A chemical change in certain of the elements of our food. 2. The introduction of air into the stomach. 3. A viscid covering to the food, to enable it to glide freely along the dorsum of the tongue into the pharynx, in the act of deglutition, and from the pharynx through the œsophagus into the stomach. It is the more viscid saliva from the submaxillary, sublingual, and small glands, whose ducts open into the anterior part of the mouth, in which the two last-mentioned are chiefly effected, and into which fluid the food is rolled in the final act of mastication preparatory to deglutition.

But it is the first-named office of the saliva, the chemical, that most concerns us; and this is chiefly found to be possessed by the more watery secretion of the parotid glands, the position of the orifices of whose ducts (Stenon's) are so situated, that the food becomes well mixed with it, whilst undergoing comminution by the molar teeth.

The action of the parotid fluids is expended chiefly in converting the amylaceous constituents of our food into grape sugar—an action which is suspended when the food undergoes another form

of change in the stomach, but which is resumed in the duodenum and small intestines generally, when it is again exposed to analogous fluids from the pancreas and Bruner's glands.

Now, I believe, the change going on in the food whilst in the mouth, through the agency of the saliva, and especially in those portions which are detained there by lodging between the teeth, or in fissures in the enamel, communicates a molecular disturbance to those portions of a tooth which have had their vitality lowered, whether through disease of the dental pulp or periosteum, by exposure of the dentine through injury, or congenital deficiency of enamel, by exposure to frequent and considerable changes of temperature, by having suffered severe concussion, or by any other cause that might at all interfere with the normal condition of their nervous or nutrient supplies.

I am not disposed to refer this altered condition of the tooth-substance to necrosis, because we find necrosed tooth-substance, or bone, very unsusceptible of undergoing change. It may be in the condition in which we find ivory, which readily undergoes absorption when introduced into the substance of the bones of animals (a condition not improbably like that the temporary teeth are in at the time they are undergoing absorption); or in that in which the stomach may be immediately after death, when digested by its own

gastric juice; or in a condition analogous to the tissues which suffer absorption in the line of demarcation, when a mortified part is undergoing a natural separation. A condition I have occasionally remarked in some teeth would almost seem to suggest a fatty degeneration. We know calcareous degeneration of these organs to exist; but my observations have been too limited to do more than suggest a probability of the former.

The conclusions I have therefore arrived at are, that certain portions of our food, especially bread and vegetable substances generally, owing to the changes continually going on in their amylaceous constituents in the mouth, may, by their continued contact with a tooth in the abnormal condition just spoken of, communicate a change to its particles, and induce in it a disintegration or decay. I do not deny that the presence of a free acid may not assist, or even be necessary to this change, as we find it is in the digestion of food in the stomach; but that acids are not the sole, or even the most important agents in this process, I think the following experiments will clearly show.

A number of recently removed teeth having been obtained, the carious and softened portions of the dentine were carefully removed, leaving only the hard dentine exposed. Several teeth thus prepared were placed in glass vessels loosely corked as follows:—Those placed in vessel 1 had

some roast meat finely divided, and water introduced with them. Vessel 2 had the same, only some saliva was added. To those in vessel 3 a strong solution of cane sugar was added. Vessel 4 contained the same, with saliva added. Vessel 5 had, besides the teeth, a small quantity of bread and water; and vessel 6 the same, with saliva added.

These vessels and their contents were exposed to a temperature of about 100° Fahr. (that of the mouth) for a period of twenty days, and then examined, when the contained teeth presented the following conditions:—Those in vessels 1 and 2 had undergone no change whatever, the dentine being quite as hard as when put into the vessels; the meat had undergone putrefaction, and the fluid was strongly alkaline. The teeth in vessels 3 and 4 were thus affected: — In 3, the change in the dentine was so slight as to be scarcely appreciable; but those from vessel 4, where, we remember, saliva had been added, had the exposed dentine considerably softened. The contents of these two vessels were strongly, though, I should say, about equally, acid. The greatest change, however, I found in the dentine of the teeth from vessel 6, where to a small quantity of bread and water saliva had been added. The softened dentine could readily be removed in thickish flakes. Vessel 5 had its teeth in about the same condition as were those

in vessel 3; the decomposing teeth had probably effected to a small extent the same results as the saliva had. The fluid in vessels 5 and 6 was only slightly acid. The result of these experiments must, I think, lead us to dismiss from our minds the necessity for insisting on the presence of a free acid as the sole cause of dental caries. The teeth contained in vessel 6, immersed in a fluid only slightly acid, were much more altered and softened than those in vessel 3, which were exposed to a far more acid fluid. The character of acid in the last fluid, also, ought to have been chiefly that which is known to possess a considerable solvent action on phosphate of lime; but, as the decomposed bread in vessel 6 would probably also have generated some of the same acid, the liquids from both were subjected to analysis—when the saccharine fluid was found to contain by far the larger quantity of lactic in addition to other acids.

Finally, microscopic appearances seem to confirm these views. A comparison of sections of dentine from the three following sources,—viz. (1), from a carious tooth, (2) from a tooth removed from vessel 6, and (3) from a tooth decalcified by an acid,—showed a far greater resemblance between the two first than between the last and either of the former.

A point of some interest in these experiments is the apparent greater destructive action of the

commonest article of our food, bread, than of either of the two other substances experimented with. If the inferences I have drawn from them be correct, the frequent cleansing of the mouth with mild antiseptics ought to prove very beneficial.

The gradual breaking up of the dentine after it has become softened is, I think, better explained by the views here advanced than by any other; and we can also readily comprehend from them how the discharges, and decomposing particles separated from a carious tooth, may induce the like condition in the contiguous surface of a neighbouring tooth, which we so commonly find to be the case in practice.

I do not deny the possibility of disease arising in the bony portions of the teeth, from causes wholly unconnected with the presence of external agents, and which may resemble the diseases that occur in (it is true, the more vascular substance) bone. Specimens that have been preserved seem to prove it really to have taken place in the dentine; but I believe such cases are rather the exception than the general rule.

It is my intention, in addition to the repetition of the experiments here described, to institute a variety of similar ones to ascertain the action of different articles of food on the teeth, the results of which I shall be happy to communicate at some future meeting of this Society.

GENERAL MONTHLY MEETING.

Monday, May 6, 1861.

W. M. BIGG, Esq., President, in the Chair.

The following Gentlemen were duly elected Members of the Society :—

Mr. Henry Howard Hayward, 56, Queen Ann Street.

Mr. R. E. Stewart, 37, Rodney Street, Liverpool (non-resident).

The following Gentleman was proposed for the Membership of the Society :—

Mr. W. Fisher ..... 13, Crescent, Taunton.

The following Donation was made to the Society :—

Mr. Wheeler.—A Specimen of Dilaceration in a lateral Incisor of the Upper Jaw.

GENERAL MONTHLY MEETING.

Monday, June 3, 1861.

W. M. BIGG, Esq., President, in the Chair.

The following Gentlemen were proposed for the Membership of the Society:—

Professor R. Owen, F.R.S., British Museum.
Mr. E. M. Tweed, 11, Brook Street.
Mr. F. H. Balkwill, Canonbury, Islington.
Mr. W. Pearce, 9, Unity Street, Bristol (non-resident).
Mr. W. Hunt, Pen Villa, Yeovil, Somersetshire (non-resident).

The following Donations were made to the Society:—

Mr. E. Parkinson.—Three lower Molar Teeth, each with three fangs; also a large piece of Salivary Calculus.

Mr. C. J. Fox.—Model of Infant's Jaw, showing two lower Incisors through at birth.

Mr. Laurie.—A specimen of Allen's continuous Gum work.

Mr. Truman read a paper

On the Necessity of Plasticity in Mechanical Dentistry.

Mr. President and Gentlemen,—The subject of the present paper has now been long before the profession, and has taken several forms: which is the best, or whether the best is yet known, remains for us to determine; but that plastic dentistry, in some form, will be admitted now to

be essential, I feel we shall all agree. In laying my subject before you, I shall not endeavour to give a detailed account of the various means of attaining plasticity, as this would be useless and tedious,—all that I could tell, you know; I shall simply point out the most prominent methods, and endeavour to show the various steps which have been taken, and give them, as far as I am able, in the order in which they appeared in this country. I mean, by plastic dentistry, an arrangement by which the mouth may be fitted with artificial teeth, through or by the direct means of plastic materials, either permanently retained, or afterwards replaced by others of a more durable nature.

On the 11th of May, 1791, appeared in England the first use of a plastic material for the construction of artificial dentures. M. de Chemant, as you all know, proposed mineral paste moulded to a plaster model, and afterwards, when dry, carved to imitate teeth, and then vitrified. The property of clay to shrink in baking was, however, fatal, or here would have ended our labours, for in a very short time all that we require this substance would have fulfilled; but this one fault has cost us seventy years' labour, and is not fully overcome yet. Mineral paste is, and I think always will be, one of the most useful and beautiful materials we have, and we should be wanting in gratitude to M. de Chemant not to

award him our acknowledgment and thanks for so valuable an introduction.

The true plastic principle was not, however, at all apparent in M. de Chemant's plans; it was simply making of porcelain what had before been done in bone. So I shall not occupy more time with this part of my subject at present.

In 1845, Mr. Tomes led us into another channel of thought, by his most ingenious application of machinery to effect with greater certainty the fitting of bone to the model. Ivory was then one of our best materials; its lightness and congeniality would give the greatest known comfort, if the base was well fitted. This Mr. Tomes sought to do, without the liability to failure always attendant on manual dexterity, and thus surmount the difficulties arising from the non-plastic nature of this material.

I now arrive at what I believe to be the first introduction of the plastic principle.

In 1848, the importation of gutta percha into this country had led to its use for many purposes, and to a series of experiments by myself, with the view of rendering its manifold peculiarities, and especially its plasticity, conducive to the advancement of mechanical dentistry. These experiments have occupied myself and others ever since, nor are they now concluded; but the results thus far, it is my intention to lay before

you to-night. I shall therefore resume this part of my subject in its proper place.

August, 1849, Mr. Harrington took out a patent for the use of tortoiseshell. He endeavoured to overcome the great difficulty of the bite by using temporary hollow sets filled with wax, instead of the usual modelling-pans; and then, by a very clever contrivance, registering the dimensions requisite in the finished structures, which were to be mineral sets made entire, and fitted on a base of tortoiseshell made plastic by heat, and whilst in that state, forcibly compressed on to the metal model. This substance, not being plastic below boiling point, the whole plasticity of the plan depended on the wax filling the temporary sets, and the capability of moulding the shell to the model.

1850 produced a suggestion from Mr. Dimsdale to construct the gold coating by means of dies. In this plan we have a further slight development of the plastic principle, after the use of wax to raise the model or predicator. *Predicator*—I propose the word predicator as a name for that wax or other plastic structure raised, as in vulcanite, to predicate or predetermine the size, shape, and absolute conformation required by the mouth in the finished structure. He fitted this to the mouth, and then proceeded to cast plaster forms for the purpose of striking up his hollow metal gums. Here plasticity is confined to the

wax gum, but it is the first use of plaster casts from the predicator in this country of which I have any knowledge.

In 1853 Mr. Laurie introduced the continuous gum, mineral paste filling the interstices between the teeth and plate, which, on being hardened by fire, renders the whole structure one piece. In this we have our old plastic material beautifully used; its one fault, shrinkage, thus far entirely overcome, but its plastic property only conducive to beauty.

Mr. Loomis, in 1854, sought to make whole dentures on M. de Chemant's plan, and to rectify the shrinkage by cutting the plaster model through transversely, and again uniting the halves with a piece of wood of the desired thickness glued between; and this operation being repeated longitudinally, would give an increase both in the length and breadth of the model.

These were quickly followed by vulcanite and metal alloys and tin, the plans of using which are essentially the same: to which the priority should be given I do not know. In each of these plans, a predicator is reared on the model in wax, with the teeth that are to be used in the finished case; a plaster matrix produced, and filled either by casting in metal or packing in vulcanite; lastly, various imitations of ivory in 1859, and collodion in 1860, all used much after the same fashion, but all fitted to the best model

that the operator could procure. These bring us down to the present time; and I think I have enumerated all the plastic plans proposed: from which we see that—

Up to the year 1848 the use of plastic materials for this purpose was practically unknown. Experiments had been made, but without practical results; in fact, so totally unlike anything then in use was the plastic system that it required some courage to introduce, take up, or use materials so contrary to received usage. I remember the late Mr. Claudius Ash, on my first mentioning to him my intention of using gutta-percha, asking me if I intended it merely as a means of publicity, as it surely could not answer in practice. The employment of gutta-percha has been the means of introducing plastic materials into dental practice, and may yet itself alone in many cases be found the best substance for the purpose, under proper management. How to treat substances so entirely new could only be arrived at by time and constant perseverance.

I promised, in a pamphlet published in 1849, to give the profession the results of my working, and I now propose to do so.

The great aim of the dentist in making artificial dentures is to render them useful as aids in mastication, and therefore to that point I will at present confine my observations, as the

perfect comfortable fitting of the base to the gum must be obtained before that great object can be achieved.

The first step, after the mouth is properly prepared for artificial teeth, is to procure a good model. This I think, in many cases, an utter impossibility, unless you remove sound teeth—useful teeth—teeth that, but for artificial aids, you would plug with the greatest care if they were decayed, in the hope of retaining them—for such would be good practice. I am sure you will go with me in repudiating any such interference. What, then, is to be done? The best model that can be got must be taken; and the question is, how? Many substances of a plastic nature have been proposed to model with—wax; composition of wax and mastic; other compositions; gutta-percha, alone or prepared; plaster: which is the best, depends on the case; but in the irregular mouths, among that forest of irregular teeth, none can do it perfectly. In how few cases a near approach can be obtained you all know. In this lies the great difficulty of fitting artificial pieces that are to be useful in mastication. The best workman can only fit his model; and if that is not like the mouth, what is to rectify the difference? Sometimes, the more perfect the fit to the model, the worse the fit to the mouth, as the imperfections of the former are too closely copied to allow comfort in the latter.

I have only one remedy to propose to you against a bad model, and that is, to use a substance which can be fitted direct to the mouth itself, either in the construction of a perfect predicator or as the base of the permanent artificial teeth: but of that more hereafter.

In simple cases, without much loss of structure, with short remaining teeth and a close bite, the old gold plate, modified by modern improvements, is still the best.

For front teeth, pieces of two or three teeth, if not pivoted, when the remaining teeth are good and no back ones lost, unless the teeth are very long, I prefer a modification of the old French plan, without a plate; and these are almost the only cases in which plasticity is not wanted; so, not to occupy your time too long, I shall say no more about them. For masticating teeth placed artificially, especially in the lower jaw, if we would have our patients eat in comfort, plasticity must be used in one form or another; either we must, as in the case of vulcanite, horn, tin, and shell, use it as a means for defining and arranging the form and size of the piece, or we must, as in gutta-percha, apply it to the finishing and fitting of it finally in the mouth itself. Wax, as a medium for mounting teeth preparatory to the fixing, was in use before the introduction of the plastic principle; but its real value as a plastic medium, except in modelling, was not understood.

It is now through this substance that the system is carried out, and it is by its instrumentality that we are now able to mould non-plastic but more durable materials for our purpose, and thus arrive at greater exactness with much less skill and trouble. I think, in all the plastic systems, wax is chosen as a material with which to raise the predicator, or temporary structure. Other substances could be employed, but wax is the best; or it may be mixed with other matters to harden it, and so enable us to get a better finish; for I need not say, that the more perfect the wax is, the less is left to be done afterwards to the hard or durable substance by which it is replaced. This, in fact, is in all cases, except when gutta-percha is used, or electro-gilding, as described by me in the specification of my patent of 1848, the stage in which plasticity is alone obtained. In many cases, it is, as now used in vulcanite, sufficient, especially if you can get a good model, as by it the after form of the piece is determined, the arrangement and antagonization of the teeth definitely fixed; and as these are the vital points on which depend the whole success of the operation, it follows that, with a good model to give the perfect shape of the base, plasticity, by facilitating the arrangement of the other and more difficult points, enables us to arrive at much greater perfection than was possible without, and is therefore a very great advantage.

Now, let us suppose a case. The upper teeth are all gone—the lower front teeth alone remain; —you take models of the mouth, and arrange the bite in the usual manner; the model for the upper may be obtained by any of the materials proposed —some prefer plaster, but all admit that it is highly necessary for the model to be a good one, especially if no springs are to be used. Much ingenuity has been expended in the hope to get a good model of these edentulous upper jaws, which are the easiest of all to model; but even in them it is impossible to get two of the same mouth exactly alike, which I take to be positive proof that neither is correct. But we will suppose, to save time, that we have fortunately got a good model.

For such an upper set, vulcanite is peculiarly adapted: used plastic, as we all understand, and hardened by heat, a perfect, steady, firm fit may be obtained with the greatest facility.

The teeth are first mounted on wax to the right height, size, shape, and position. Thus far we have a structure entirely plastic, which can be arranged to the bite perfectly and most easily. The shape so given being retained in the finished case, the temporary piece may be fitted on a metal plate and tried in the mouth, and regulated to it before being plastered up; for when a non-plastic substance is to be used permanently, every advantage should be taken of mobility whilst it is

present. I sometimes carry this principle so far as to allow the temporary piece to be worn and used for some days before stereotyping, as we may call it, by producing the vulcanite set from it in the usual manner. If we wish to do this, of course wax will not answer; use gutta-percha instead, and have all the teeth mounted on a skeleton metal frame, which will keep them in their proper place, and afterwards be imbedded with them in the vulcanite, and impart very great additional strength. All the peculiarities of the mouth can be complied with, the form of. the arch arranged to please the eye, and benefit the form of the face: a little more bulk is added here, a little less used there; this tooth is a little too much in, that too much out. All these defects and any others are easily rectified; friends are consulted, the most satisfactory conclusion is arrived at, and then the piece unalterably fixed, without any chance or guess work, or without re-making, unless from accident;—duplicate permanent sets may even be obtained exact from one predicator. The vulcanite is light—I mean, of a low specific gravity; the teeth are very firmly set, and, with skill in the making, it is a good and cheap method of replacing the upper. For the lower teeth I think it is better also to use vulcanite than not to use a plastic agent in some form; but I do not think it the best; I prefer gutta-percha, or any other substance which can

be moulded to the mouth itself: for in upper cases used without springs, the most important point, after a good fit to the gum, is a good bite; and this can only be attained perfect by having the lower set made of or with a material which will allow, while in a plastic state, that the upper set bite the lower to the right height. This it does if gutta-percha is in contact with the gum in sufficient thickness to allow the teeth to sink when bitten on. With your permission, therefore, I proceed to describe the making of such a lower set:—Take a strip of gold plate, about the thickness of a new half-penny, three inches long by half an inch wide. This I bend flat, to fit the inner surface of the lower teeth and gums, it remaining perpendicular; I then solder a bar of copper between the back points, to prevent them opening during the next process of hammering the centre into an external concave surface, the concavity extending back almost to the ends. This is done on a triblet hollowed on the top, into which the gold is hammered; when finished thus far, it will represent half of a tube bent on itself, with the concavity outwards, and of a size that will not go into the centre of the model till it is filed to fit the lower teeth. This is the next step; and in doing this, I do not recommend that the fitting be too accurate, but care must be taken that the thickness in front under the tongue behind the front teeth is not too prominent, or it will be

complained of in speaking; but it must be enough to insure perfect strength, which in all artificial pieces is a first principle. Having selected the teeth, and cut the lower ends round as though they are to be let into the bone, I mount them in their appointed place with wax, and fit the gold to them as I have before done to the front teeth; next solder strips of gold at the sides in the hollow of the gold semi-tube externally, horizontally, to receive the pins for the teeth, and mount them (but without fitting) as you would on an ordinary gold plate; if necessary, put on the joints for springs, and then cut out all the superfluous plate from between the teeth, and finish the gold by removing all that can be taken away consistently with perfect strength; next, and lastly, solder a strip of open mesh platina gauze into the hollow in front of the gold behind the front teeth, and finish by polishing all the gold convex surface which will be exposed after the gutta-percha is on; great care should be taken to have the teeth not too high, but fitted with a good bite rather too low. Remove the wax, and clean the plaster model thoroughly; fasten on the teeth with cement and silk, or by any other good way. Now put on the gutta-percha, pressing it firmly on the model, to insure density and closeness in all parts, to make it quite solid: on this depends the sweetness. Have too much stuff to begin with, or place another layer under, and again make the

whole hot, so that it be just plastic, and then again consolidate it by pressure on the model. Now, without touching it, put it, model and all, in water, and let it get cold. To trim and finish, cut away all the superfluous gutta-percha with a hot knife (but not hot enough to burn it, or you will injure the beauty), and smooth the surfaces with the finger dipped in soap and water. Your case is now ready for the mouth; in placing it in which, proceed thus :—

Of course, all care will have been taken that the upper and lower agree in the bite, and that all the points essential in every artificial piece have been well attended to. Have near you a vessel of boiling water, and another of cold; also a spoon or ladle, to remove the piece from the hot water without handling it: I prefer one with the bowl bent at right angles to the handle, and perforated with large holes. Place the piece on the spoon; dip it in the hot water till it is soft enough, but no more; then remove, and passing it through the cold water, place it carefully in the mouth, and press it forward to the front teeth, to insure its being in its right place. Now put in the top set, and direct the patient to bite steadily, being sure that both pieces antagonize properly. Keep the mouth shut till the gutta-percha cools, or at least solidifies.

Do not handle it, but let the mouth do its own work, and trim it after it is again cold.

The effect of this arrangement will be a perfect fit at the base, and exactly the right height in the bite; for should the height be too much, by gently warming and biting it will go down till it is right; and if, on the contrary, it is too low, another layer can easily be added to the under surface, and the operation repeated, which will bring it right. Also, it is quite certain that the masticating teeth will properly act on each other, as the lower can readily be altered by moving to either side, or by bending till they do: this cannot be done without a plastic base, or, in fact, with vulcanite. These remarks apply also to full under sets.

In small cases of two or three teeth at the side of the lower or upper, all will admit, even the public, that nothing is easier than to replace them with gutta-percha; and I think it will be also admitted by us that there exists great difficulty in these cases without it—almost always the remaining teeth overhang the space between. In these cases the gum is so very narrow that any uneven pressure is unbearable, therefore it has been customary to place rests on the remaining teeth, and thus keep the pressure off the gum, and in some instances to put clasps around the teeth to prevent lateral motion. But, with all these contrivances, failures often occur, even with vulcanite, where a plastic material can be well adapted to the model. I will quote a few

words from a periodical published a few weeks back, to show what the public thinks on this matter :—

"It is very possible, however, to replace, for all practical purposes, very considerable chasms in the grinders with gutta-percha; and the best of it is, if the dentists will permit me to say so, that it is capable of application by the patient himself. Front teeth cannot be thus replaced; but suppose a man has lost two or three of his back ones, and cannot afford to have them supplied by a dentist, I would advise him to act thus: — Let him take a lump of gutta-percha about as big as a walnut; warm it thoroughly in boiling water till it is as soft as putty; then putting it into his mouth, let him bite it well into the gap, and keep his teeth closed till the gutta-percha cools. This will oblige him to shut his mouth for two or three minutes; then let him open it carefully, and take the lump out; he has only to trim it down with his pen-knife, and he will be fitted with an excellent substitute for regular artificial teeth, which will serve him for years. This is no theory, but proved fact; and I can only account for its not being more generally known and realised, by its interference with the regular business of the profession. Forgive my entering into details, but the presence of jagged stumps rather assists this operation than

otherwise, for they steady the gutta-percha superstructure."

And which of us can deny the truth of these remarks? Not I; for during the last twelve years I have repeatedly seen such pieces, made by the patients themselves, replacing others made in the best manner on the old plan. An eminent counsel told me, the other day, that he had done so; and one of the highest functionaries of the present time did it for himself ten years ago, and has used them ever since. Of course, teeth should be placed in such pieces; and for so doing, it is only necessary to mount two or more teeth on a bit of plate, and imbed the whole in gutta-percha on the model; then trim as usual; and after again warming, place the piece in the mouth, and allow it to cool: it will, if well done, be quite serviceable as long as the mouth remains unaltered. I have seen such a case, after it had been during five years and ten months in the mouth without removal, perfectly good, the mouth quite healthy; and on removal, it would have required a close observer to find that an artificial piece had been used.

The irregularities of the remaining teeth, as I before said, form the greatest obstacle in fixing artificial teeth; and, unless we remove them, I know no better method of effectually getting over the difficulty than to use, as I have shown, a plastic material, such as gutta-percha, and mould

it directly to the mouth, as in that method the irregularities are beneficial.

Now let us say a few words about upper-part sets. I will suppose another case:—

All the front teeth remain, all the back are gone; what shall we do with it? Make a bone set or a gold plate? If so, how hold the case steady?—by a chamber, if gold, or by wooden pegs for bone? No; vulcanite is far preferable to either, for it is lighter, and the back of the front teeth can be well fitted. This will hold the case steady; and with a good model and a well-constructed predicator, it will certainly be better than either bone or gold;—than bone, because it is more durable and easier to make; than gold, because there will be no necessity to put clasps on the canines. I should do it with gutta-percha; but I do not wish to intrude on the notice of the Members of this Society, who are so much better able to teach me than I to instruct them, a matter of mere opinion in practice. Nevertheless, I have only one wish, which is to benefit the wearers of artificial teeth—improve myself and our art, by opening a discussion on what I believe to be the vital point of Mechanical Dentistry; I mean, plasticity.

Whole top sets without springs, I have said, are especially the property of vulcanite; but for part sets of one or two teeth on each side of the upper, and a tooth or so in front, with short bites,

in young people, it has not strength enough without great bulk. Perhaps some will say, strengthen it with metal; I would say, use a gold plate in front, and gutta-percha sides; and as this is a very common case, almost an every-day affair, and will, perhaps, more clearly show what advantage the patient derives from plasticity than any other, I will again, with your permission, state how we proceed to make such a case, a description of the manufacture being the easiest and most intelligible form that I can adopt in treating a mechanical subject:—

I think the first thing to be done towards making an artificial piece is to select the teeth, for many reasons; first, to be sure we can get the right; and if not, that our after-work may be arranged for those we can get. This vulcanite has rendered imperative when the material is used, and I would do it in all cases. Excuse my reiterating in so learned a society what I consider the first principles on which these dentures should be formed: I mean, perfect comfort, strength, lightness, neatness, durability, beauty, easy adaptability, and natural effect, with perfect health to the surrounding parts. The first governs all the rest; but even it is useless without durability, and the maintenance of health in the surrounding parts. What was comfort in the old time, bought at the cost of a tooth a year? In all future experiments on this subject, these first principles

must none of them be ignored. I do not hope to live to see perfection in them all achieved in every case, for that would be to see Mechanical Dentistry perfect. We, in this room, and our Transatlantic brethren, have in our time done much; but it is for a future generation to arrive at perfection, or in reducing dentistry to a science. Still, we cannot hope to improve if we shut our eyes to the fact that the above points must, in a great measure, be all fulfilled in every case. And let us see now how far I have kept to my own laws in the case before us. First select your teeth, some for the front, perhaps tube teeth with gum, or half teeth with or without gum; let them up into the place they are to occupy on the plaster model. Now let us see how much room we have in the bite for the means to hold the teeth in their place. Perhaps there is not room enough even for a gold plate between the lower front teeth and the upper gum when the mouth is shut; it may be necessary to perforate the plate, to let the lower front teeth through or partly through, or there may be ample space. Now, in the first case, vulcanite could not be used with any hope, as the bulk would keep the back teeth from closing; therefore, I would place all the teeth in their places on the plaster model with wax, except those that were to have nothing between them and the gum, and have them fitted to the lower teeth in the bite; then strike an ordinary gold plate, but

very narrow, and cause it to cover the backs of the remaining teeth some distance up, and also the inner surface of the back artificial teeth and wax supports. Now fit that plate to the bite; and if the front lower teeth must go through, let them through. You will now have a skeleton plate, which, if strong enough, would carry your artificial teeth. But it is not strong enough; therefore, it must be made so. Now, it happens by good fortune that the natural teeth stand out of the gum almost at right angles; therefore, in most cases—I will not say in all, but in most—there will be a part of the plate left all along the base of the teeth, forming with that turned on the gum an angle with the concavity inwards. This angle must be filled solid; and thus a triangular bar of metal will be formed, passing behind, but not necessarily touching the remaining teeth; and in only very few instances will it be found requisite to give more strength; but, whatever strength the case requires must be given at this period; but not a particle of superfluous metal should be left, as neatness is another of our principles; as much as is requisite we must have, and no more. We have thus attended to the teeth, and the plate to hold them in their places; we have now to put them together, and to ensure durability and comfort; one point of which is, that, when finished, the structure should be firm in the mouth. How shall we get this without

using clasps to the other teeth? At present, in all cases we cannot do it, but we can in a great many; and when we must do something of the kind, they need neither show nor injure the other teeth. If we have a front tooth or teeth lost, together with some on each side, but not the back ones, of course they will not be required at all, as the fit of the plastic material in the back openings will be enough to keep them steady; but if it is requisite, be sure to fit the opening between the canine and lateral, or canine and bicuspid, or any other little interstice that may exist about that part of the mouth, very accurately, even placing a small portion of gold to project between the teeth from behind; this, in all cases, will be found quite enough. Now put on the side pieces of gold to support the pins for the back teeth, if pin teeth are used, as before described, when using my semi-tube for the lower; if half teeth, let them be soldered in the ordinary manner to the gold plate; replace the wax with gutta-percha, and you have a piece that is the smallest, lightest, strongest, most durable, most comfortable, and least injurious that I can conceive, constructed upon what I term the true plastic principle, because all the materials are treated as though they were plastic, even though they are not so, and a piece is produced which, in the mouth, is to all practical purposes quite plastic; where defects existed in the model, the gutta-percha will rectify, and the

fit is as even as though the whole arrangement had been fitted in a plastic condition.

It may be said, at least durability cannot be ensured if gutta-percha is used, and that no case made of gold can be so light as one made in vulcanite or bone; and it may also occur to some to ask, Are these very small cases less detrimental to the remaining teeth and soft parts of the mouth? I will begin by answering the last question first.

My experience shows they are less injurious, because they are lighter, and, from their accuracy of fit, do not place an undue strain on any one part; the remaining teeth are left quite free, and the mucous membrane of the palate uncovered; there is no accumulation of effete epithelial cells or lodgment of food. And I would ask, in return, What is the use of the plate in such cases if it is not required for strength?—and that it is not, I think I have fully demonstrated; and as comfort without it is immeasurably increased, I hope you will all give this plan a fair trial before you again put into the mouth a single grain of superfluous material. Next, to take the same reverse order, are they lighter? Make two cases, the one upon my plan, the other on any other, and weigh them, both having the necessary amount of strength; the result will answer the question in my favour if my directions have been fully carried out.

And now for that great question, the durability

and cleanliness of gutta-percha. I have never seen gutta-percha that has become decayed whilst under water, and therefore none that became so by being worn in the mouth. I have repeatedly seen gutta-percha pieces that were very rough and dirty looking, and very offensive—even specimens of my own preparing years gone by—but I never saw it decayed in the mouth. If worn, however, for some time without cleaning, and put away in a box dry, and covered with grease, on being again heated the gutta-percha becomes sticky, and like bird-lime, and should, of course, be renewed; but if kept in water while out of the mouth, I believe the gutta-percha to be indestructible. The rough or dirty appearance, and the offensiveness, are caused by its porosity; and this only happens when it is badly treated, or, in other words, not understood. Great force should be used to put it on the pieces, to consolidate it and close the pores; this I now do under pressure. The gutta-percha being quite pure, and properly prepared to begin with, and not boiled, but merely softened—or, if the colour is not of so much consequence, softened by dry heat—and after it is finished in the mouth, the surfaces again dried, and a thin coat of amber varnish or collodion brushed over them, neither roughening nor offensiveness will occur. Any trouble to ensure the patient's comfort is not thrown away. I have used it now nearly thirteen years constantly

in thousands of cases, and latterly with undeviating success, because I have strictly attended to the rules herein laid down, and which nothing but time could develop. To put on gutta-percha under pressure, I proceed just as we should to make a vulcanite set as far as the models are concerned; but instead of putting the teeth into the mould before packing, I put in the finished gold piece with teeth all fastened on, and I use about two or three times more gutta-percha than the space will hold. Having all soft and warm, I put the moulds in the iron cases together, and force them home under a strong screw press, very slowly, but with great force. This will, of course, leave the bite too high—just what I require; for, as I said before, the mouth should regulate that, which of course it does the last thing.

I allow the gutta-percha to get quite cold under pressure, and then trim off the surplus with hot knives. If this process has been used, and the material good, it will be found quite solid; and with cleanly use, and good brushing with pumice-powder, I know nothing wear better. I know a case, now, that has been constantly used, untouched, except replacing a broken tooth, for eleven years. I need say no more about durability, but I will again point out briefly the causes of disappointment in the use of gutta-percha.

1st. Boiling it is most pernicious; it opens the pores, and leaves it a sponge.

2nd. Fingering and manipulating it in the mouth unnecessarily. The mouth will put it in shape, if left to itself, far better than we can. And,

3rd. Hurrying it. If it is taken from the mouth before it has sufficient solidity to enable it to keep its shape it is in danger of being altered before it is cold. I would therefore say, put it on by pressure, trim it carefully, warm it sufficiently—no more; place it in the mouth correctly and carefully; allow it to remain steadily pressed by the antagonizing teeth — not the fingers—till it is cool enough to remove without danger; place it in a vessel of cold water till it is quite set; trim it again to exactly what it should be; smooth the surfaces with warmth and your fingers, or a burnisher dipped in soap and water; wash it quite clean; pass it quickly through hot water, just to slightly soften the surface; place it in the mouth, and there let it remain; in an hour the patient may eat his dinner with perfect comfort, and if his mouth does not alter, certainly the artificial teeth will not. One word more. I have said, I know a case that has stood perfectly eleven years. I think, with all our philanthropy, that we should not like all our cases to endure so long, especially as the facility for adding other teeth, afterwards lost, without making new sets, or even leaving a visible patch, or rendering the fit a particle less perfect than it was originally, must make this plan greatly

less conducive to profit. I therefore say, fortunately the mouth alters if the case does not, and the comfort derived by the patient by a refit and new gutta-percha amply repairs this objection. I have a patient, known to many of you, who delights in the sensation of biting the piece into its place so much that he constantly has the surface renewed to gratify this propensity; and really the facility with which this operation is performed is so great that it becomes a source of great profit. I can put on the new gutta-percha, after the models are ready, in a few minutes; and, as you know, they can be prepared in less than one hour.

If a tooth breaks in a vulcanite set it takes more time to repair it. I would say more about vulcanite, as I think it a process in its infancy, out of which much may come; the power the workman gains when using vulcanite, or rather when using the wax in preparing the predicator, enables him so readily to form his piece accurately; mistakes are so easily rectified; the teeth can so readily be moved outwards or inwards to suit the bite; the pins not having to be fixed in holes drilled in gold and soldered, do not so much depend on the skill of the workman; and the true plastic nature of the operation is felt throughout. If gutta-percha, alone or vulcanized, is to be superseded, it must be by a plastic material, or one capable of being used through

a plastic medium; for those who use vulcanite, or tin, or gutta-percha, or any of the plastic plans, would return to the old non-plastic system with regret, having tested the sweets of plasticity. I, who use gutta-percha so much, and thereby retain to myself the power over my work to the very last, could not now be happy without it; it makes the day's work a delight, difficulties a pleasure, and failure my own fault.

But, lately, so much has been written and said about vulcanite that I felt I should interest you more by complying with a desire that has been often expressed to me to tell my experience in gutta-percha; and I do so the more willingly, as it is the only substance yet known plastic in the mouth, and, therefore, carrying my subject—plastic dentistry—to its highest point; I believe, in fact, it is capable but of one improvement—the power of retaining a polished surface. But what material will retain a polished surface in the mouths of careless patients? Not even gold; and in very many cases it leaves nothing to be desired. But I do not plead the cause of any particular substance; I only now, as at first, maintain that Mechanical Dentistry cannot be perfect without the plastic principle, in one form or another; and I cannot tell you what amount of pleasure I derive from the knowledge that I have been the humble means of working so great a change; and I am also pleased to be able to add that I have induced

the Gutta-Percha Company to put up the necessary machinery to produce pure gutta-percha for dental purposes. This removes the difficulty of procuring the substance properly prepared, which has always been one of my greatest obstacles; and it would be quite impossible for dentists to do this part of the operation for themselves; it would be easier for them to make their own vulcanite, as in that case the caoutchouc or gutta-percha used need not be pure.

I have endeavoured to tell as much as the short time allotted to one paper would allow; but I feel the magnitude of my subject demands both more time and more ability than have fallen to my lot. I hope during the early part of next session it may be followed by other papers from abler hands, not written hurriedly, as mine has been, in the height of the London season, and that it will lead to a thorough investigation into the value of the various plastic materials proposed, and a series of discussions on Mechanical Dentistry.

GENERAL MONTHLY MEETING.

Monday, November 4, 1861.

W. M. BIGG, Esq., President, in the Chair.

The following Gentleman was duly elected a Member of the Society:—

Mr. William Fisher, 13, Crescent, Taunton (non-resident).

The following Gentleman was proposed for the Membership of the Society:—

Mr. H. Campion, 305, Brighton Place, Manchester (non-resident).

The following Donations were made to the Society:—

By Samuel Ghrimes, Esq.—Dried preparation, exhibiting dissection of nerves and blood-vessels of the teeth; ditto, second dentition. Skull and lower maxilla of spaniel; ditto of another dog; ditto of cat; ditto of osprey; ditto of guinea-pig; ditto of American squirrel; ditto of hedge-hog; ditto of rabbit; ditto of hare. Skull of tortoise. Two elephant's teeth; section of ditto, showing laminæ of enamel. Interesting case of exostosis in tooth of walrus.

By Walter Campbell, Esq., of Dundee.—An "Articulator," of which the following description was read:—

This articulator is only necessary when there are no antagonizing teeth in the mouth. The advantages obtained by this instrument are the following:—

By it the bite can be lengthened or shortened from that taken in the mouth, and still correspond to the opening and shutting of the jaws.

The models can be taken off, and put on again

in two or three seconds, so that with one articulator, two or three dentures can be gone on with at the same time, and the same bite may be referred to at any future time, should a duplicate be wanted, or the original piece require repairing.

The advantage given by the articulator with the forward and backward motion is not great, it should seldom be needed; before transferring the bite to the articulator, the operator should be pretty sure that it is correct, but it will occasionally happen that the operator fears that the under jaw of the patient was a little too far out when the bite was taken. Having transferred the bite to the articulator in the usual way, he will again try it in the mouth—and his doubt may be realized,—when all that he has to do is simply to slacken the screw and push back the under part of the instrument until it corresponds to the position in the mouth.

The india-rubber washers on either side of the joint give a near approach to the grinding motion of the jaws without rocking in any degree.

The method of transferring the bite to the articulator is as follows:—Cut a shallow cavity in the upper model a little wider at the bottom than at the top, about three-quarters of an inch or an inch square at the bottom; place the model on the table, bottom uppermost, rest the square of the upper limb of the articulator over the cavity, so that the median line of the model will coincide

with the line of the upper limb of the articulator; lay the pin over the square in the groove, holding it *in situ* by the thumb of the left hand; pour a thin batter of plaster into the cavity, over and above the pin, till the plaster is about an inch above the square. When set, trim off the plaster above the square, so as to allow of the removal of the model. Then place the bite with its corresponding plate—gold or gutta-percha—on the upper model, place the under model (having had a cavity previously cut in the bottom) upon its corresponding plate, turn over the under part of the articulator to the bottom of the under model, place the pin in the groove, and pour a batter of plaster into the cavity, and finish in the same way as in the case of the upper model.

When a complete upper denture is wanted, my method of obtaining the antagonizing model is as follows:—An impression of the under teeth is taken along with that from the upper jaw, from which plaster models are made in the usual way. The gold plate is then struck up—or if for vulcanite, the gutta-percha plate is adjusted—with a rim of wax sufficiently broad to receive an impress of the under teeth, then cut away until all the teeth touch the wax at the same time. The wax may then be crossed over the flame of a spirit-lamp, so as to soften the *surface*, and again placed in the mouth, the patient at the same time being directed to close his jaw naturally, until the

points of the lower teeth make an impression in the wax. This done, the models are to be adjusted to the articulator with plaster, as before directed; with this difference, that the teeth of the under model are to be gently pressed into the impression made in the rim of wax by the corresponding teeth in the mouth; then fix the under model to the lower part of the articulator with plaster, as before.

The following was read by Mr. Tomes:—

On Certain Conditions presented by Amalgams used in Filling Faulty Teeth.

The unqualified condemnation of amalgams on the part of some, and the confidence reposed in mercurial fillings by other dental practitioners, is a sufficient indication that the question has not received that amount of investigation which its importance merits. We meet with cases in which teeth filled with amalgam have lasted for fifteen or twenty years, indeed, until with the advanced age of the patient the teeth have loosened and fallen out. But far more numerous are the cases in which the presence of the amalgam fillings have failed to arrest, for any considerable time, the destruction of the teeth. With opposing opinions and inconclusive results, it is incumbent on those who regard the use of amalgams with unqualified disapprobation to show the grounds upon which their condemnation rests; we should

be told why amalgams fail to preserve the teeth into which they are introduced; and it should be clearly pointed out that the conditions necessarily involved in the use of these mercurial compounds are such as must secure an unfavourable result. On the other hand, those who advocate the use of amalgams should be able to point out why the unfortunate so far outnumber the successful cases. Why, in one case, an amalgam filling preserves a tooth for an indefinite time, while in another case the disease is arrested but for a few months. To say that these differences in the results depend upon accidental causes is but to admit that we are unacquainted with the conditions, the presence or absence of which will determine, in each case, the success or failure of the treatment.

In cases of failure, it is not enough to condemn the material used in the treatment, unless it is at the same time shown that the employment of other materials would have led to a successful issue. Dental surgery has arrived at that point when mere opinion, unless supported by clearly-stated evidence, cannot be accepted as a guide for practice. To analyze one by one all the conditions attendant upon the operation of plugging a tooth, and those to which the tooth is subsequently exposed, is by no means a simple or an easy task. The recognition of a difficulty is, however, in many cases, the first step towards

its solution; and although we may be unable to acquire a perfect knowledge of our subject, yet we may, and no doubt shall, make great advances from the point at which we at present stand. The rate of progress will, I feel sure, be hastened by our devoting ourselves to the investigation of special points, which, after being worked out by individuals, should be brought before this Society for free and ample discussion. With this feeling, I undertook to prepare for the Society a paper upon the physical conditions presented by the different materials used in filling teeth. I did so with the hope of throwing some further light upon the use of amalgams, but more especially with the hope of inducing others to take up, for the purpose of close investigation, this and other points of practice.

To treat of amalgams satisfactorily, it would be necessary, in the first place, to consider the different amalgams as chemical compounds, both as respects the substances used in compounding each amalgam, and the proportions of the several ingredients. I, in common I believe with many others, purchase and use materials prepared by Messrs. Ash or those of other makers, without knowing the proportion the incorporated metals bear to each other. Whether definite proportions exercise an important influence in these compounds, in which mercury plays so singular and important a part, I am unable to determine; but

the fact that in certain alloys the proportion in which the ingredients are combined will determine whether a chemical combination or a mere mixture results, indicates that the question of proportions should be fully investigated.

The consideration of proportions will involve the investigation of the nature of the process by which the hardening of the compound is effected. It is usual to state that this process is one of crystallization, but I am not aware that anyone has shown that crystals are formed. Whether an amalgam in hardening either expands or contracts is also a question of great practical importance; and the character of surface retained by the mass when its induration is complete cannot be neglected. It is to the investigation of these latter points that I have directed my attention. The experiments instituted have been confined to the amalgams in general use, with the view of ascertaining the merits of well-known compounds, and of making them the basis of comparison in the examination of combinations which may at a future time come under our notice. But even here, at the very threshold of a very simple inquiry, we are most of us met by the difficulty of ignorance. We are, for the most part, dependent for our supplies upon those who prepare amalgams for sale, and who, in the interest of their trade, do not proclaim the formulas they follow. We are, in fact,

daily using amalgams concerning the ingredients of which we have no precise knowledge. To each of these imperfectly known compounds we attach the name of their respective makers—a custom which, in itself, shows pretty clearly that we are not proceeding upon very scientific principles—that we trust to the knowledge of the compounder, who is unacquainted with the results of practice, rather than to our own knowledge, both for the determination of the ingredients used, and of the relative quantities of the component parts. In conducting the experiments the results of which I am about to lay before the Society, the following plan has been adopted:—Slips of ivory have been prepared, the size of each being similar, except in a diminished width, to the ordinary glass slide used for mounting microscopic preparations. Each ivory slide is perforated through its centre by a perfectly cylindrical hole. When about to be used, the slide is firmly clamped down upon the flattened surface of a block of ivory, by the assistance of which the cylindrical perforation is converted into a cylindrical cavity—having a perfectly flat floor lying at right angles to the walls. On the under surface of the slide several minute angular fissures have been cut into the edge of the wall of the cavity by a very small four-angled file. This expedient has been adopted for the purpose of testing the readiness with which the amalgams used enter minute fissures.

The amalgam has been introduced with ordinary care, and forced into the experimental slide with a round-headed burnisher sufficiently small to enter with readiness the cavity.

When the amalgam has perfectly hardened, the clamp is relaxed, and the slide withdrawn from its position on the block of ivory, thereby exposing for examination that portion of the plug which rested upon the floor of the cavity, together with the fissures in the walls produced by the file.

The amalgams in general use may for convenience be arranged into two groups: those which are combined with mercury as a preliminary proceeding, the mass being softened by moderate heat, and the excess of mercury squeezed out prior to the introduction of the plastic mass into the tooth; and those which are completed by the addition of the mercury to metallic filings at the time of use. Of the former kind I am aware of two varieties only: the one formed by the solution of pure copper in mercury; the other, Sullivan's cement, compounded, it is said, of copper mainly. Each of these has been subjected to the experimental test already described, and with the following results:—In test slides Nos. 1 and 2, the amalgam, when it has hardened in contact with the ivory forming the bottom of the cavity, presents a fine granular surface. It has failed to penetrate into fissures

extending from the sides of the cavity in the one slide, and in the other it has separated from the wall of the cavity. In neither slide is the cavity fully and entirely filled. The microscope shows that the plug is in neither case perfect. In slide No. 3, the pure copper and mercury were introduced. The process of hardening has not in this case been attended either with the same amount of contraction or of change of surface as in the preceding specimens, in which Sullivan's cement was used. Indeed, this specimen exceeds any other I have examined, both in respect to the smoothness of surface it preserves, and to the closeness with which after hardening it is applied to the surface of the cavity in the ivory slide. In slides Nos. 5 and 6, an American amalgam, sold by Messrs. Jameson, of Glasgow, was employed. This compound has hardened in contact with the ivory with a very rough, granular surface, and the mass has obviously contracted, so that had the surface been such as when closely applied to the walls of the cavity would have served to exclude the ingress of moisture, the general contraction would have rendered that property useless. In each case the filings were carefully rubbed with the mercury in a mortar, and the mass when perfectly incorporated was, previous to introduction, washed with ammonia.

In preparing slide No. 8, the filings sold by Messrs. Ash were incorporated with mercury in

a mortar, the mass washed in ammonia, and then, after the expression of the superfluous mercury, introduced into the test slide. The result is a plug, presenting a fine granular surface where hardened in contact with the ivory, and a considerable amount of separation from the walls of the cavity, the obvious result of contraction.

In slide No. 9, the same materials were employed, but the combination was effected by rubbing the filings and mercury together in the palm of the hand. The washing was also omitted. The result, due to the difference of manipulation, is a plug, presenting a much rougher and more granular surface than No. 8. It is separated from the walls of the cavity, and the mass has failed to enter the fissures prepared to test its powers of penetration.

Slide No. 10 contains an amalgam furnished to me by Mr. Jameson, and consists of the following ingredients:—tin 10½ dwt., silver 1 oz., gold 1 dwt. The filings were incorporated with the mercury in a mortar, and subsequently washed with ammonia, the excess of mercury squeezed out, and the mass introduced into the cavity in the manner described. The bottom of the plug showed a broken and granular surface, and an incapability of penetrating into minute fissures.

Specimen slide No. 11 contains a plug introduced by our treasurer, Mr. Rogers. It consists of pure palladium and mercury, the two metals

having been combined by friction in a mortar. In this plug there are obvious indications of contraction. I am indebted to Mr. Rogers for a second specimen of No. 12, in which the results are more satisfactory; but in this, the metal has not penetrated into all the fissures. The surface presented by each of the palladium plugs is very finely granular, but not in this respect superior to the copper amalgam.

In producing the specimen plugs, the operation has in each case been conducted with care, and the results are quite as favourable as would have been obtained in the course of practice. Having discovered the difficulty of forcing an amalgam into minute fissures, I might by specially directed efforts have obtained more successful results, but my object has been to test the qualities of the several compounds when employed in the treatment of carious teeth, with the usual amount of care. I may mention that if an excess of mercury be retained, with a view of rendering the operation more perfect, the failure will not be less pronounced. The mercury will be squeezed out into the fissures, leaving the solid metal behind. Again, if the mass be deprived of mercury, so to render it crumbly, the surface of the resulting plug where resting against the walls of the cavity, will be broken and irregular.

My investigations up to the present time lead to the conclusion which an examination of the speci-

mens before the Society will, I think, fully justify, that our present knowledge respecting the compounding of amalgams suitable for dental purposes is in a very unsatisfactory state. Take, as an example, the two specimens of palladium plugs, in each of which the composition is supposed to be similar, while, owing perhaps to slight differences in the manipulation, or to the quantity of mercury used, a want of uniformity in the results has been produced. Again, a plug produced by rubbing mercury with the filings prepared by Messrs. Ash, in the palm of the hand, varies considerably from another in which the mercury and filings were thoroughly incorporated in a mortar, and the mass washed with ammonia. When the uncertainty in the character of an amalgam plug is admitted, and the difficulty in forcing the metallic paste into fissures or minute angles is acknowledged, we need not, I think, be at a loss to account for the difference of opinion which prevails respecting the durability of amalgam plugs generally, and respecting the comparative excellence of the several kinds of amalgams.

There are those who prefer, before all others, the pure copper amalgam, and if regarded for its physical properties only, it unquestionably stands in the foremost rank; but the black colour it assumes and imparts to the tooth, and the strong metallic taste its presence in certain cases establishes, justify its condemnation; still, notwith-

standing these objectionable qualities, I doubt whether we should be able to find amalgam plugs which have preserved teeth for a greater number of years than such as have been composed of copper and mercury. A palladium plug, if produced under the most favourable circumstances, is in its physical characters equal to one of copper, and the great superiority in its chemical character places this amalgam at the head of the list. At the present time, the metal is so rare that its general use, even in the quantity which might be required for dental purposes, is prohibited. So far as my own limited experience has gone, the qualities of the samples furnished have varied. In some cases the mass has hardened with such rapidity that an insufficient time has been allowed for its introduction into the tooth; in other specimens the hardening process has extended over some hours —a variation suggestive of differences of composition.

I rarely use amalgams in teeth which admit of the introduction of a gold or tinfoil plug; in other words—in teeth which afford a reasonable chance of preservation, and in the treatment of which the qualities of the material used would be fairly tested. Although my experience in the use of amalgams is limited to the results obtained in the treatment of unpromising cases, I am fully prepared to support the opinion that these compounds

are of great practical value. The issue of the experiments I have laid before the Society points to sources of failure, and at the same time affords satisfactory evidence in favour of the impression, that a more accurate knowledge of the properties of these metallic compounds, and a more careful manner of use, would greatly increase the value of amalgams in the practice of dental surgery. I hope to bring before the Society a continuation of these observations, and trust the members will consider the subject sufficiently important to engage their attention in the investigation, and that they will be induced to institute experiments, both as respects the properties of amalgams, and the best methods of using them. Our efforts should, in the first instance, be directed towards the production of a metallic paste, which will receive and retain after hardening a perfect counterpart of whatever surface it is pressed upon. It should have no surface, granular or otherwise, peculiar to itself. It must be free equally from contraction and expansion during its gradual induration; and, in addition to these properties, it must resist such chemical agents as may be applied to it in the mouth.

It is possible that the materials at present in use may, under certain conditions of treatment, combine all these properties. If so, these conditions are not generally known. It remains

for me to tender my thanks to those gentlemen who have kindly furnished me with specimens for experimenting upon, and to state that those preparations upon which I have made no report will receive my attention on a future occasion.

GENERAL MONTHLY MEETING.

Monday, December 2, 1861.

W. M. BIGG, Esq., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Professor R. Owen, F.R.S. (Honorary.)
Mr. F. H. Balkwill ... Canonbury, Islington.
Mr. E. H. Tweed ..... 11, Brook Street.
Mr. W. Hunt ..... Yeovil, Somersetshire (non-resident).
Mr. W. Pearce ..... 9, Unity Street, Bristol (non-resident).

The following Gentlemen were proposed for the Membership of the Society:—

Mr. S. C. Gibbons, 13, New Burlington Street.
Mr. J. J. H. West, 69, Old Broad Street.
Mr. J. J. B. Bate, Brighton (non-resident).
Mr. W. Campbell, Tay Square, Dundee (non-resident).
Mr. O. A. Fox, 12, Pavilion Parade, Brighton (non-resident).
Mr. W. V. Moore, 15, Princes Square, Plymouth (non-resident).

The following Donation was made to the Society:—

By Mr. Cattlin.—Metallic models illustrative of retarded dentition and supernumerary teeth.

Mr. Broadway exhibited some specimens of soft rubber attached to the gum surface of the vulcanite base.

Mr. Cattlin introduced a case of retarded dentition in a youth aged fourteen years and nine months; the whole of the temporary teeth in the lower jaw were retained, while the second dentition in the upper jaw proceeded in the normal manner.

Mr. Coleman brought before the Society a case of fistulous opening of the antrum into the mouth in the situation of the first molar tooth, which he treated successfully by a plastic operation.

The following paper was read by the Foreign Secretary, from Mr. Belisario, of Sydney :—

On Diseases of the Pulp.

Mr. President and Gentlemen,—In the December number of the "British Journal of Dental Science" I perceive the attention of the Society has been actively directed to the treatment of diseases of the dental pulp; and as the subject is highly interesting to us all, and a large unexplored field to work upon, I propose in the present short paper to lay before you my practice in filling when the pulp is irritable, or merely covered by a layer of disorganized dentine, and which I have practised for the last six years with a very large amount of success. I am aware there is nothing novel in the treatment I am about to lay before you, it having originated with Dr. Dwinelle and Prof. Arthur, and that it may be the practice of many other gentlemen; but when our aim is to advance the general good of the profession, it can only be accomplished by freely communicating our different experiences.

A patient comes to us, complaining of his tooth—he has had a sort of grumbling in it, not exactly tooth-ache—he gets pain on taking sweets or acids, and cannot take comfortably anything above or below the temperature of the body in his mouth; in fact, he has all the symptoms of irritability of the pulp. This is the class of cases that is oftener presented to our notice than those of

suppuration of the pulp,—this state of the organ being brought on from change of temperature, acidity, and fluids filtering through the partially decalcified tissue. In short, when, in the course of excavating a carious cavity, preparatory to filling, if I proceeded to remove all the disorganized tissue over the pulp, and by so doing would expose it in the slightest degree, I invariably allow it to remain, I do not mind however softened or decomposed a state it may be in; the practice of Drs. Dwinelle and Arthur, in such cases, was to cap the pulp with gold, and fill over in the ordinary manner. In my hands it has not been so successful, unless coupled with risodontrypy at the time of the operation. If my patients are in town, and I have opportunities of seeing them, I employ the following means:—Should the dentine over the pulp be in a softened and decalcified state, with tenderness on pressure, I have employed the following remedy, with marked advantage,—the application on cotton wool of Tinct. Ferri Mur., sealing it in, and renewing it for two or three days, and have generally found on examination that the tenderness had subsided, or in a great measure so. I then proceed to fill the tooth, keeping it very free from moisture, with a preparation of gutta-percha and tannin worked up together, and dismiss my patient for six weeks. The advantages of this plan are, if active symptoms should supervene, the filling can be easily removed and the case treated, though in a very small number

of cases it has been necessary to do so. If at the expiration of the time appointed I still find tenderness, I refill again in the same manner. I have seldom had occasion to repeat the filling more than twice, for it will generally be found that, under ordinary circumstances, in from six weeks to three months, the disorganized tissue has become hardened, from a deposition of the salts of lime. I think this mode of treatment will afford us, in favourable cases, some data as to the time calcification usually takes place.

I quote one illustration of a well-marked case of the sort, that occurred in January, 1860. The lady of one of our judges consulted me respecting a right upper molar diseased in the masticating surface; she had suffered one or two twinges of pain and uneasiness on taking hot or cold fluids, sweets, &c. I removed all the carious portion, except that immediately over the pulp, which was much softened, and prepared the walls thoroughly; there was some tenderness on pressure. I filled the tooth. The lady called on me two days afterwards; she had slight pain, and was fearful it might increase. I removed the filling and applied the muriated tincture of iron, and allowed it to remain for two days, then refilled, and dismissed her for three months. She returned on May 2nd; had been quite free from pain during that period; the filling was slightly worn from mastication, otherwise in good preservation. On careful ex-

amination there was not the least tenderness; the disorganized tissue had become perfectly hardened, and was of a lightish-brown colour. I placed a non-conductor of asbestos at the bottom of the cavity, and filled permanently with crystal gold. One year has now elapsed, and I see my patient frequently; she has been perfectly free from any pain, and the tooth is thoroughly useful and comfortable. I could give many similar cases were it necessary.

While I am on diseases of the pulp, it may not be out of place to give you particulars of a most interesting but decided case of failure, and which resulted from extreme irritability of the pulp, brought on through transmission of temperature, and which I really could not have foreseen. A gentleman, æt. 33, requested me to fill two right upper molars, and one on the left, also a right lower molar; they were all SLIGHTLY diseased on the masticating surface. I filled them in two sittings. There was nothing that called for any special attention in this case. I drilled out the diseased matter, which was very slight, and filled. I must here observe, that the cavity in each was so small that I never for one moment thought of applying a non-conductor; in fact, there would have been hardly room for the filling had I done so. He returned to me three weeks afterwards—had been suffering intermittent pain in his head, neck, and ear. I made a careful examination of

the filled teeth; there was no difference of sensation under percussion from the others, no pain on taking hot or cold fluids. He said he did not think it originated from the filled teeth. I applied a strong counter-irritant to the gum opposite the teeth, and prescribed a brisk aperient. I saw him again in a week, in consultation with his medical attendant. He had been something better for a day or two, but I suspect it was only while the mind was diverted by the remedies. I again made a most careful examination, and could detect nothing by manipulation or questioning which would warrant me in removing the fillings. It was the opinion of his medical attendant that he was suffering from neuralgia, and he left me to be treated for it. I did not see him again for six weeks; he had been very unwell, and had been taking constitutional remedies, combined with change of air. He now directed my attention to a swelling over the filled teeth, it had come about a fortnight before I saw him, since then all pain had ceased. The cause of all the mischief was at length apparent—an abscess over each tooth in the upper jaw. The pulps of the filled teeth must have been exceedingly irritable, and have proceeded to suppuration without any of the usual symptoms of general inflammation of the organ, the filling being no doubt the exciting cause, by transmitting changes of temperature. I felt strongly inclined to remove the dead pulps and fill the fangs, but, on mature considera-

tion, I thought it would be wiser, as he had already suffered so much, to extract the teeth, which I did. I may remark, that I removed the filling in the lower molar, inserted a non-conductor, and refilled. Some months have now gone by, and he has been perfectly free from all inconvenience. I must again reiterate, that there was such a depth of bone over the pulps that no one would have thought of applying a non-conductor; the pains which he described in the head and ear were evidently sympathetic. This patient was of a very excitable and irritable temperament. Failures are often more interesting than successful cases; this is a most unique one.

JOHN BELISARIO, D.D.S.

ANNUAL GENERAL MEETING.

Monday, January 6, 1862.

W. M. BIGG, Esq., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Thomas Bell, Esq., F.R.S., Selborne, Hants (Honorary).
Mr. Henry Campion, 305, Brighton Place, Oxford Street, Manchester (non-resident).

The following Gentleman was proposed for the Membership of the Society:—

Mr. S. Amos Kirby ..... Huntingdon.

Mr. W. A. Harrison, the late President, presented his Portrait to the Society.

The following Gentlemen were elected by ballot as Officers and Council for the ensuing year:—

President.—John Tomes, Esq., F.R.S.

Vice-Presidents.—(Resident) S. Cartwright, Esq.; Edwin Saunders, Esq.; T. A. Rogers, Esq. (Non-resident) T. G. Palmer, Esq., Cheltenham; Robert Brookhouse, Esq., Manchester; C. Spence Bate, Esq., Plymouth.

Treasurer.—Arnold Rogers, Esq.

Librarian.—J. B. Fletcher, Esq.

Honorary Secretaries:—*Foreign Correspondence.*—Alfred Canton, Esq. *Ordinary.*—G. A. Ibbetson, Esq., and Alfred Coleman, Esq.

Council.—T. Underwood, Esq.; W. A. N. Cattlin, Esq.; J. R. Mummery, Esq.; Robert Hepburn, Esq.; W. A. Harrison, Esq.; J. H. Parkinson, Esq.; Charles Vasey, Esq.; Charles Rogers, Esq.; J. Deacle Saunders, Esq. (resident.) W. K. Bridgman, Esq., Norwich; George Parkinson, Esq., Bath; R. H. Moore, Esq., Dublin; Richard White, Esq., Norwich; D. D. Hepburn, Esq., Nottingham (non-resident).

GENERAL MONTHLY MEETING.

Monday, February 3, 1862.

JOHN TOMES, Esq., F.R.S., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Mr. Siles Clifford Gibbons, 13, New Burlington Street.
Mr. John Thomas Henry West, 69, Old Broad Street, City.
Mr. Walter Campbell, Tay Square, Dundee (non-resident).
Mr. O. A. Fox, 12, Pavilion Parade, Brighton (non-resident).
Mr. W. V. Moore, 15, Princes Square, Plymouth (non-resident).

The following Gentlemen were recommended by the Council to be elected as Honorary Members:—

J. M. Arnott, Esq., F.R.S.	Dr. Sharpey, F.R.S.
J. H. Huxley, Esq., F.R.S.	Dr. Porteous.
J. H. Green, Esq., F.R.S.	Professor Goodsir.
W. Laurence, Esq., F.R.S.	Sir C. Trevelyan, K.C.B.

The following Gentlemen were proposed for the Membership of the Society:—

Mr. John H. King, Cambridge House, Portsmouth (non-resident).
Mr. Henry J. Virgin, 63, High Street, Oxford (non-resident).
Mr. John Wheeler, High Street, Portsmouth (non-resident).
Mr. W. Broadway, 23, Gilbert Street.

The following Donation was made to the Society:—

By Mr. Spencer Cockings.—Thirteen volumes on subjects connected with Dental Surgery.

Mr. Coleman read a paper—

On Anæsthesia, considered especially in reference to operations in Dental Surgery.

Mr. President and Gentlemen,—The subject of anæsthesia, whilst undoubtedly of great interest

to the medical profession generally, is one which addresses itself with peculiar interest to the Dentist, when it is considered that the early experiments which laid the foundation for the discovery of this, the greatest boon that has ever been conferred on suffering humanity, were carried out by those engaged in this department of surgical art.

That greater attention should have been devoted by the Dentist to the subject of performing operations without pain than has been bestowed by those practising general surgery, may be explained when it is remembered that operations undertaken by the latter are usually either for the removal of a deformity, or for that which, if permitted to remain without interference, would probably shorten existence. Personal vanity in the former, and love of life in the latter instance, are inducements which have seldom failed to determine patients to submit to them. In the case of a painful tooth, neither of the above considerations usually applies. The patient hopes the pain may cease, and then he will be as before: he knows that the operation of its removal would be of but very short duration, yet he dreads those few seconds, and wishes he could pass through them in a state of unconsciousness.

That the operation of removing a tooth is attended with as severe a pain, during the short

period it lasts, as perhaps is felt in almost any operation, is not to be wondered at, when it is considered that in detaching it from its socket the dental periosteum is lacerated and contused between the unyielding fangs and their alveoli—a membrane supplied with branches from that nerve, which so high an authority as M. Brown-Séquard regards as the most sensitive in the body, and we know that crushing a nerve is far more painful than incising it.

Although it is not the object of this paper to enter into the history of anæsthetics, which has already been done by those who have devoted treatises to the subject, we may briefly remark that, if we except the occasional employment by the ancients of certain drugs compounded of preparations of the mandrake, Indian hemp, and some others which they kept secret, the first suggestion which laid the foundation for all that we have since known of this subject emanated from our illustrious countryman, Sir H. Davy, who recommended a gas, nitrous oxide, commonly called laughing-gas, to be inhaled in order to remove pain in surgical operations. In the year 1844 this suggestion was acted upon by Mr. Wells, a dentist of Hartford, in Connecticut, though with only partial success. Dr. Morton, also a dentist in America, and formerly a partner of Mr. Wells's, in conjunction with Dr. Jackson, of the same country, experimented with the

vapour of ether, the effects of which had for some time been known to be similar to those of nitrous oxide gas, and with complete success.

The first operation performed in this country under ether was also by a member of our profession. The introduction of the so-called chloric ether, in the year 1847, by the late Mr. Jacob Bell (whose assistance in the formation of this Society I trust we all gratefully remember), has, I think, failed to receive the merit it deserves. Mr. Bell employed it at the Middlesex Hospital, where several dental operations were performed under its agency. Had the nature of this compound been fully known at the time, the cause of uncertainty in its action would have been discovered, and chloroform brought under the notice of the profession. This discovery, however, was left for Dr. Simpson, of Edinburgh, whose labours in the work of rendering operations painless cannot be too highly praised. It will, I think, appear that the dental profession has played no unimportant part in the introduction of general anæsthesia, whilst its members have probably bestowed a still greater share of attention to producing the more desirable condition of local anæsthesia.

What is really required to extend our knowledge of this subject, which at present is very imperfect, is a more accurate observation of the effects of anæsthetics under different circum-

stances, and more careful records of those cases which unfortunately have been attended with fatal results.

On the grounds of its more certain and speedy action, as well as of its agreeable odour, chloroform is the anæsthetic generally employed. Its effects have usually been divided into four stages; but as there is no sudden transition from one stage to another, the accounts of observers do not all accord.

From my own observations, I should say that the first stage commences with rather agreeable sensations, derived from the first few inhalations, though attended with a feeling of suffocation when too large a quantity of the chloroform is employed: a feeling of warmth is soon felt about the region of the thorax; the intelligence is but slightly impaired, and the senses not much altered; the patient sees and hears most of what is going on around him; the pulse is generally accelerated, and respirations are hurried and irregular. He often feels the pulsations of the cerebral arteries like strokes of a hammer upon his cranium. This stage ends, and the second commences with singing in the ears and tingling in the extremities; a mist rises up before the eyes, and the patient becomes unconscious; combined with these, there are frequently muscular movements, often excessive and most purposeless; the patient talks or shouts, commencing

a sentence and losing his ideas before he has had time to complete it. The pulse I have usually noticed to become very feeble towards the close of this stage. In the third stage we have complete unconsciousness; the muscular movements are replaced by rigidity; the eyelids are commonly closed, the pupils contracted, and the eyeballs turned outwards and upwards as in sleep; the pulse usually recovers itself at this stage, and the respirations are quiet and even. Stertorous breathing, accompanied with dilatation of the pupils, constitute the fourth stage. Beyond this is death, a stage which fortunately I have never witnessed.

The effects on the nervous centres in the different stages are, I believe, somewhat as follows:— Towards the close of the first, the cerebral lobes are chiefly affected, as are also those nervous centres through which we appreciate pain— whether through suspension of the function of the grey substance of the spinal cord, which is supposed to convey the impressions of pain, or of some nervous centre through which it is appreciated, I will not venture to decide. In the next stage the centres of the various senses are impaired; and from the character of the muscular movements, I should apprehend the function of the cerebellum was interfered with. In the third stage the spinal cord first suffers irritation, producing muscular spasm, often resembling tetanic

convulsions; but as it proceeds it fails to respond to stimuli, as in the fourth stage, where reflex action ceases, except that of respiration, which continues only so long as the office of the medulla oblongata is preserved, which terminates at the end of the fourth stage.

I would not insist that this order is followed out in every case of anæsthesia produced by chloroform, but I believe it applies to the generality of cases, my conclusions having been drawn from observations on about a thousand administrations that I have witnessed.

From the great diversity of opinion which prevails respecting the action of chloroform on the blood, little appears to be known on the subject. Some contend that chloroform replaces oxygen in the blood, and, by preventing its being arterialized, interferes with the proper nutrition of the nervous centres, and, consequently, with their proper functions; others, that it prevents the carbonic acid being given off at the lungs, producing the same effects upon the nervous centres as the deficiency of oxygen. Many have believed it to be due to carbonic acid formed by decomposition of the anæsthetic. One writer, Dr. Jackson, of Boston, is of the opinion that the chlorine of the chloroform replaces oxygen in the blood. A variety of phenomena lead us, I think, to believe that the first mentioned is probably the true effect of chloroform in the circulation: thus, if an animal be made to

breathe hydrogen gas, all the effects of anæsthesia are produced; in this case carbonic acid will be given off at the lungs, but no oxygen absorbed, and the nervous centres when called upon to act fail to do so perfectly; anything that prevents perfect oxydation of the blood produces anæsthesia, and this whether it be accomplished by withholding oxygen or by supplying its place with some other agent, as nitrous oxide, oxide of carbon, sulphuret of carbon, carbide of hydrogen, chloride of carbon, &c. In the act of strangulation, the latter stage is one of anæsthesia: persons who have been resuscitated have stated that after a few moments of great pain, from inability to breathe, a most agreeable sensation has followed, in which a colour of magnificent crimson hue or crimson flame has come before their eyes, no doubt the effects of congested retinæ. Blood injected from the external jugular vein into the internal carotid artery produces anæsthesia. If the effects of anæsthetics were due solely to the carbonic acid formed in their decomposition, such gases as hydrogen and nitrous oxide ought not to produce the state of insensibility which they do. The advocates of this view have reasoned solely on the fact of carbonic acid being an anæsthetic. If chlorine, as Dr. Jackson, of Boston, supposes, replaces the oxygen in the blood, then it ought to be detected in the gases expired from the lungs. I have tested for it, but have never found it. Chloroform

appears to be absorbed at the lungs and given off again as such by the same organs. Chloroform may act as such upon the nervous centres of the body in a way unknown to us; and it is urged by some, that the effects of narcotics introduced into the circulation through the alimentary canal support this view. They may, however, also act by preventing proper absorption of oxygen, or uniting with it so as to prevent its action on the nervous centres when required; we know that small quantities of stimulants, and certain narcotics, prevent a waste of the tissues of the body.

Much difference of opinion prevails as to the best method in which the vapour of chloroform should be administered, some contending for the simple plan of allowing the fluid to evaporate from a handkerchief or piece of folded lint, others recommending the employment of an instrument: each has its advantages. The lint or handkerchief is easily procured, and the patient often less terrified than when an instrument is applied over the face: this is occasionally very important, when it is desired to administer chloroform without the patient's previous consent or knowledge. The advocates for the employment of instruments point out the advantages of being able to administer the agent more regularly; and when properly constructed, they prevent the patient breathing over again the air that has just left the lungs, which a moist handkerchief or lint causes

to hang about the head or face; where an instrument is used there is less chance also of the face being excoriated from the chloroform touching it. With the instrument a great economy of chloroform is effected, and as in it there is a much smaller evaporating surface, the surrounding air is much less impregnated with chloroform than where the handkerchief or lint is employed—an important point when dangerous symptoms present themselves, and the immediate access of fresh air is required. The best form of apparatus is that of a bag from which air containing the proper proportion of chloroform—about four per cent.—is inhaled, but such an apparatus is not a very convenient one for carrying about. The instrument I have usually employed is Dr. Snow's portable one. These before you on the table are the ones most commonly in use.

But the most important point connected with the subject of anæsthesia, and one that bears directly upon the question before us, is that of the danger of its proving fatal—a circumstance which has led some eminent surgeons to express feelings of regret at its ever having been introduced, and others to pronounce its use unjustifiable, except in what are termed capital operations.

In considering this part of our subject, let us endeavour to ascertain in what proportion fatal cases occur. Dr. Snow informs us that in his practice he administered chloroform about four

thousand times, and met with two deaths, neither of which he considered due to the effects of this agent, and from his accounts of them, one at least certainly appeared to be due to other causes.

Dr. Simpson, in the article "Chloroform" in the last edition of the "Encyclopædia Britannica," though he does not actually give the proportion of fatal cases, says: "Occasional disagreement with, or deleterious influence upon, one in ten or twenty thousand is no sound argument against other patients benefiting from its employment."

Dr. Kidd, who has given great attention to this subject, states that he has witnessed about eleven thousand administrations, and has seen only two deaths. At St. Bartholomew's Hospital I calculate that chloroform has been administered, in round numbers, about five thousand times, and there have been two fatal cases. In the Crimea, according to M. Flourens, chloroform was given in twenty-five thousand cases without a bad result.

There is little doubt but that many of the deaths attributed to chloroform have resulted from other causes than the deleterious effects of that agent. Shock, loss of blood, and other causes which before the introduction of anæsthetics killed patients on the operating table, should be taken into account, so that, perhaps, one death in ten thousand might not be far from the correct proportion.

How does chloroform kill? is a question as differently answered as most connected with this subject. Dr. Snow was of opinion that it did so by its direct action on the nervous centres of the heart, causing paralysis of that organ. Dr. P. Black, in a pamphlet entitled "Chloroform: how shall we ensure safety in its administration?" expresses his belief that all deaths from it are due to asphyxia, arising from spasmodic closure of the glottis, caused by the irritating effects of the chloroform when not sufficiently diluted with air. He regards it as similar to the mode of death which an animal suffers when immersed in a vessel containing a large proportion of carbonic-acid gas, the irritating effects of which cause closure of the glottis, and prevent the escape of carbonic acid from, or entrance of oxygen into, the lungs. The same effect occurs in drowning: the water entering the larynx causes closure of the glottis. Dr. Marcet, in a recent paper in the "Medical Times and Gazette," advances the view that this agent, when taken into the circulation in certain doses, will, like alcohol, cause spasmodic closure of the glottis. It is very encouraging to see a physician with the practical knowledge of chemistry which Dr. Marcet possesses, directing his attention to this subject. Some refer the source of death from chloroform, or at least many cases of it, to carrying the administration too far, until the function of the nervous centres controlling the muscles

which effect respiration is suspended and the muscles paralyzed. Probably animals are thus killed by it, when we see the muscles expanding the ribs first, and the diaphragm next ceasing to act, the heart beating some few seconds after the latter has stopped.

Another mode of death is when the blood is unable to give up its carbonic acid to the air in the lungs, which is too highly charged with vapour of chloroform; arrest of the blood in the capillaries will take place, and the right cavities of the heart becoming distended with venous blood, it ceases to act. It is probable that deaths have occurred in all the ways here mentioned; but the first noticed—viz., that where the heart's action is arrested through the direct agency of the chloroform upon the nervous centres—is unfortunately the one least under our control, and does not always appear to be due to any disease in that organ.

The conditions, I believe, most important for the safety of the patient in administering chloroform differ somewhat essentially from those that have been advanced by several high authorities. It is my belief, but I express it with much diffidence, that the more slowly, within certain limits, chloroform is administered, the safer will be the condition of the patient—the view held by the late Dr. Snow, by Dr. P. Black, and by those who consider that death usually occurs through spasm

of the glottis. Dr. Simpson, on the other hand, in the article on "Chloroform," before referred to, states, "the principal error committed in using chloroform in surgery consists in giving it at first in such small doses, or so slowly, as to keep up a state of excitement, instead of inducing a true state of anæsthesia." Dr. Kidd, also, whilst he deprecates the employment of large quantities of chloroform, appears to disapprove of the plan of inducing anæsthesia slowly, as prolonging the generally admitted dangerous stage of excitement. In this stage the heart's action is usually more excited, and respirations more frequent and irregular, so that a larger quantity of vapour may be taken suddenly into the circulation, than in the later stages, where the action of these two organs is moderate and regular. My own experience, however, does not at all convince me that the stage of excitement is longer or more severe when the chloroform is administered very slowly; on the contrary, I believe there is less excitement altogether, than when it is administered rapidly. My friend, Mr. Lloyd, who holds the appointment of administrator of chloroform at St. Bartholomew's Hospital, adopts this plan, and I think with much success.

The vapour of ether, although it has, without doubt, proved fatal in some cases, is, probably, a safer anæsthetic than chloroform. It is not impossible but that its inability to produce anæsthesia

rapidly, constitutes the true ground of its being a less dangerous agent. Chloroform, mixed with ether, is much used on the Continent. In some cases chloroform diluted with alcohol is employed with advantage; its effects, I should imagine, would not be very different from those produced when it is largely diluted with air.

In addition to the precaution of administering chloroform slowly, I would recommend its not being carried further than is absolutely necessary to produce anæsthesia, which is, I believe, very commonly done. From certain experiments made upon myself, and from watching the effects of chloroform upon others, I feel convinced, that in the majority of cases, if not in all, the sense of pain is removed before that of touch, and even before the complete absence of consciousness. That different nervous centres are the seats of pain and of the sense of touch, has, I think, of late been pretty clearly established. In support of this view, I may mention a few cases bearing upon this subject. On one occasion I administered chloroform, at the request of Mr. Laurence, to a patient from whom that surgeon removed some enormous growths from the external organs of generation with the ecraseur. When the patient was sufficiently under the influence of the chloroform, three of these instruments were applied, and the racks moved at the rate of four times in a minute; the whole operation lasting about forty

minutes. During the greater part of it the patient was sufficiently conscious to be aroused to answer a question put to her with some degree of correctness; but she felt no pain whatever. In another operation, under the same gentleman, I administered chloroform to a girl from whose upper jaw a growth partly fibrous and partly vascular was removed. During the latter part of the operation, when the surface of the denuded bone was being destroyed by the actual cautery, the patient had recovered much of the effects of the chloroform, and cried out as if in pain; but on complete recovery, which took place very soon after, she declared she felt no painful sensation at all. Most persons would suppose, that in this case the pain was felt, but not recollected. I am inclined to believe that the cry under chloroform is not necessarily an indication of pain, any more than the flinching or drawing away of a limb when incised under similar circumstances; but that it is a reflex action. A patient in a state of coma may often be heard to utter a sound when addressed, so a person also will answer in his sleep; an impression is made upon a certain portion of the nervous centres, and an action is produced, just as a stimulus upon a portion of the spinal cord below a point, where it is cut off from the sensorium, will produce a muscular action through motor nerves supplying the part irritated. I am in the habit of sitting up late at night, and consequently

am very heavy in the morning, and when called often answer in my sleep that I am getting up ; a form of reply I am in the habit of making when aroused. I believe this to be similar to a reflex action. A few weeks ago, I administered chloroform at the Metropolitan Free Hospital to a patient upon whom my colleague, Mr. Childs, intended to perform Symes's operation of amputation of the foot. From the very altered condition of the parts about the ankle, the operation lasted some time, and, owing to the diseased state of the tibia, amputation just below the knee had finally to be resorted to. During the operation, I was asked if the patient could feel, and, upon my replying that he could not, the patient said he could, and when contradicted, again said he could. Yet he evinced no symptom of pain when a portion of the posterior tibial nerve was cut off. During the early part of the operation, the femoral artery was compressed with the hand, for which afterwards the torniquet was substituted; as this was being applied the patient said, without any indication of suffering, "I can feel that you are pinching my leg." The sense of touch was present, that of pain absent.

I might narrate many cases of a similar kind, but will just relate what has occurred in experimenting upon myself with small quantities of chloroform. About three years ago, whilst suffering acutely from an abscess in my mouth,

I attempted to open it, but experienced so much pain in doing so, that I did not advance beyond a slight superficial incision. I then took a few inhalations of chloroform, and without any sense of pain cut through the indurated tissues about half an inch, and let out the contents of the abscess. I could distinctly feel the progress of the lancet through the structures; it felt as if I were cutting india-rubber. About two months ago, a first upper molar tooth on the right side of my mouth, from which a filling had recently come out, became rather painful; and thinking this a good opportunity for trying an experiment, I applied a pair of forceps to the offender, but they being cold, I experienced a sharp twinge. I took a few inhalations of chloroform, and then re-applied the forceps, but without any painful sensation; and, on taking one or two more inhalations, when I began to have singing in my ears and tingling in my limbs, I applied abstractive force, not very cleverly, I suppose, for the tooth came out minus its anterior fang. I distinctly felt the yielding of the alveolus, the movements of the tooth, and the laceration of the dental periosteum, but not a particle of pain. As a rule, my teeth are only removed with some difficulty, and from the amount of force I remember to have applied, I am satisfied this one afforded no exception. I once removed a tooth from a gentleman who had just drunk the

best part of two bottles of wine and some spirits and water. He declared he did not feel the operation at all, and for some time would not be persuaded it was out. I believe he was in a stage of anæsthesia very similar to that produced by a few inhalations of chloroform.

In addition to the usual precautions of making the patient unloose any portions of the dress that might impede the movements of the muscles of respiration—of not administering chloroform too soon after a meal, though the opposite extreme of giving it too long after one is perhaps worse—nothing can be more important than the endeavour to calm a patient's fears before commencing the inhalation. Fear has a most depressing action on the heart and nervous system, and this, added to the effects of the chloroform, has been undoubtedly the cause of many deaths. On this account, I think it is a great advantage to be able to tell your patient that you are not going to send him to sleep, but only to make him unconscious of pain; so that he shall know all that is going on, but not undergo any suffering. In addition to the satisfaction of knowing whether any disease of the heart exists, there is an advantage in listening to that organ, as after doing so you may, in all probability, be able to assure your patient that he will take chloroform exceedingly well; intelligence that is always received with satisfaction. Patients with valvular disease

of the heart appear to take chloroform very satisfactorily, although the existence of this, or disease of the lungs, should, if possible, make us more than usually cautious when administering it.

In employing chloroform in dental operations, the first question that may be asked is,—"Are operations on the teeth sufficiently painful to justify the employment of a means by which the life of a patient may be hazarded?" In answering this question, we naturally ask another, viz.—"What proportion of risk does a patient run who takes chloroform?" Every person who rides in a railway train runs some risk of being killed; but the risk is so small that no one feels it is imprudent to do so. We came to the conclusion, when considering the proportion of fatal cases of chloroform, that they were about one in ten thousand. As every dentist probably removes more than ten thousand teeth during the whole of his practice, if he employed chloroform in every operation, he might expect one fatal case to occur to him in the course of his lifetime, an event which no sensible man would desire. In the above proportion are included deaths from all causes, occurring whilst the patient is under chloroform, together with those that have occurred from incautious and improper administration, especially that of commencing with such quantities as ℥j to ℥ij poured upon lint or a napkin; whilst want of

knowledge or presence of mind has prevented the resuscitation of many whose lives otherwise might have been saved. I think it would be a safe rule to lay down, never to recommend chloroform for the extraction of one or even two teeth, provided there appeared nothing remarkably difficult about their removal; but not to refuse it if the patient very much requested it, and then to apply it only in the small quantity before recommended. If only carried thus far, I do not believe the proportion of fatal cases would exceed one in fifty to one in a hundred thousand. In looking over the recorded cases of those who have died after taking only a few inhalations, if we exclude those where the patient was evidently asphyxiated from an overdose of the agent, I do not think they will be found to exceed ten in number.

When, however, our patient requires four or more teeth removing at one time, our course then becomes clear, and, on the ground of humanity, unless an objection is expressed, we may justly urge its employment.

I must here make some reference to a paper by Dr. Kidd, in the "Medical Times and Gazette" of June, 1860, in which the author endeavours to point out how much more fatal small operations have proved under chloroform than large ones; but, in his calculations, he never once takes into account how much more frequently small operations under chloroform are performed than are

large operations. Take, for instance, the removal of teeth under chloroform; how many more thousand teeth are there not removed under chloroform than limbs amputated? Again, another reason why we might expect a more fatal result to small operations, exclusive of their great number, is, that they are generally performed in a surgery or ward where the same attention or appliances are not to be found as in an operating theatre, where the bulk of our large operations are performed,—at least such is my experience.

Operations on the mouth under chloroform are always difficult to perform. The patient's position, usually semi-recumbent, permits the head to fall down upon the chest; the tongue also gets in the operator's way; blood runs down the throat, exciting coughing and vomiting, as well as hiding the teeth and stumps to be removed, and often it is difficult to keep the patient's mouth open sufficiently wide for the ready introduction of instruments. Should it be required to remove one or two teeth only, the plan of giving a few inhalations may be adopted with advantage. When doing so, I usually allow the patient to hold the inhaler himself, telling him to let me know when he thinks he has had sufficient, and then to open his mouth wide, when a second or two probably completes the operation required. The patient, I think, feels much confidence from knowing he has the control of the chloroform.

When several teeth are to be removed, it is always expedient to secure the services of some person accustomed to administer the agent—the operator has too much to attend to, to enable him properly to watch the effects of the anæsthetic. When an inhaler is employed, I think ten or twenty minims of chloroform are quite sufficient for commencing with,—at least I have found it so,—and ten minims may be added from time to time as required. It is commonly the practice to proceed so far that the ciliary margin of the eyelid is not sensible to the touch; but, as this is a reflex as well as a voluntary movement, it is, as Dr. Kidd and others have shown, a test by no means well adapted for ascertaining the degree of anæsthesia: pinching also is felt by the sense of touch after that of pain has been removed. I think one of the best tests is speaking to the patient, or very slowly commencing the operation and watching its effects.

Supposing the patient to be sufficiently under the influence of the chloroform, the next step is to open the mouth and keep it open, often difficult to manage on account of muscular rigidity. To meet this difficulty I constructed, about a year ago, an instrument (Fig. 1), of which the following description was given in the "Medical Times and Gazette" of 26th January, 1861:—

"The instrument is constructed upon the principle of a pair of forceps, with this difference, however, that the handles do not cross each other

at the hinge, so that by pressing them together, the blades or short extremities are separated. About the hinge the instrument is curved upon itself. Attached to one of the handles is a spring

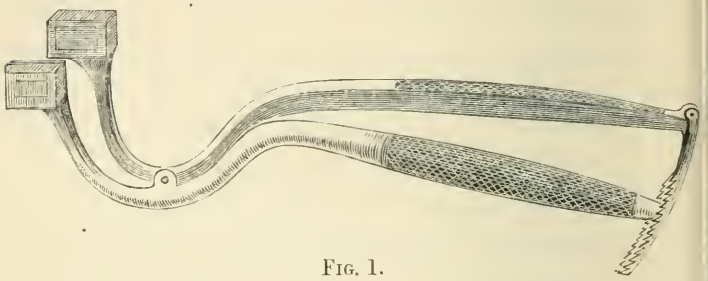


Fig. 1.

catch, which keeps the blades fixed at any required distance from each other. The extremities of the blades are made broad, and covered on their outer surface with vulcanized india-rubber. In using the instrument the handles are opened, and the blades brought together, and the latter are introduced between the teeth at the back of the mouth at the opposite side to that on which any operation is to be performed. The curve of the instrument adapts itself to the cheek, and prevents either the handles or blades being in the operator's way. By compressing the handles the blades, and consequently the patient's jaws, are separated from each other, and by means of the catch can be maintained in the required position at the will of the operator.

"The instrument was constructed and is best adapted for operations on the teeth under chloro-

form, but it has been found useful in other operations on the mouth as well.

"It possesses the following advantages: of being readily introduced into and removed from the patient's mouth; of quickly increasing or diminishing the distance of the jaws from each other; of enabling the assistant who administers the chloroform to apply this agent from time to time without removing the instrument from the mouth; of being quite out of the way of the operator; and, by means of the vulcanized india-rubber pads, of avoiding all risk of injury to the teeth or gums."

The portion of the instrument (Fig. 2) which keeps back the cheek on the opposite side of the mouth to which the instrument is introduced, was suggested to me by Professor Humphry, of Cambridge. I have used the instrument on very many occasions, and have found it invaluable; a first, and even, at times, a second molar tooth may be removed on the same side of the mouth as that at which it is introduced.

Fig. 2.

The cases we select for operations under chloro-

form are generally those where there are several difficult teeth or stumps to be removed, and the time required to effect this usually necessitates the reapplication of the chloroform often more than once, prolonging very much the operation and increasing its danger; in addition to which more blood finds its way into the stomach and excites the annoying occurrence of vomiting. I had long felt this inconvenience, and upon seeing in one of the medical journals an account of chloroform being inhaled through the nose in an operation on the mouth, I constructed an instrument for the purpose (Fig. 3), which was

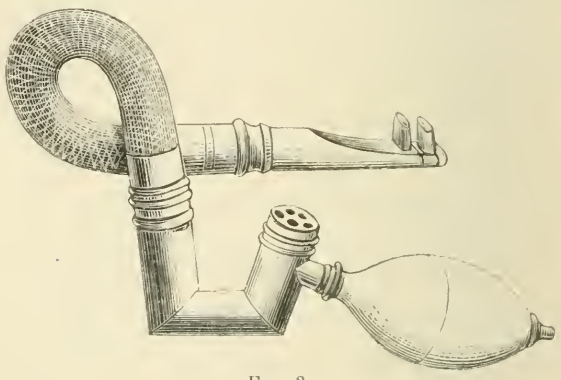


Fig. 3.

thus described in the "Lancet" of the 11th of last month:—

"The difficulty of keeping up the anæsthetic effects of chloroform in operations on the mouth induced Dr. Richardson to adopt the ingenious plan of administering this agent through the nose.

The instrument here figured is one designed by Mr. Coleman for this purpose.

"It consists, firstly, of that portion of Dr. Snow's portable apparatus which contains the bibulous paper to be saturated with chloroform; to this an elastic tube, about 10 inches long, and of the same diameter as the instrument, is fitted in the same simple manner as the face-piece of Dr. Snow. In the brass cap at the further extremity of the tube, a valve, opening outwards, is inserted. To this cap is also attached the nose-piece—a silver tube flattened upon its upper surface, and having soldered into its end, at a right angle, two smaller tubes of an oval form. These converge slightly towards each other at their extremities, and by means of a slide the distance between them may be diminished or increased. Just below the open extremity of the instrument, where the air enters and the chloroform is introduced, an elastic india-rubber bottle is connected, having a valve at each extremity, opening towards the tube.

"In using the instrument, the patient may be brought under the influence of chloroform with the face-piece attached in the usual way. When the patient is sufficiently insensible, the face-piece is removed, and the tube with the nose-piece substituted, the smaller tubes being inserted into the nostrils. In consequence of the nostril-tubes being made to approximate, they can be adapted for persons of different ages, and when introduced,

by closing them the nose-piece is held in its proper place. It having been found in some cases that when the mouth is open the full effect of the chloroform cannot be kept up, the india-rubber bottle has been added, to enable the administrator to force a stream of air through the instrument into the patient's nose. By placing the thumb on the open extremity and compressing the bottle in the palm of the same hand, this object is readily accomplished. By simply closing the opening with the thumb, the action of the instrument is immediately suspended; by partially closing it, the effects are lessened. The valve in the tube prevents the return of air which has been respired, which escapes at the patient's mouth."

This instrument was first tried, and with complete success, in a case of necrosis of the lower jaw, from fumes of phosphorus, on which occasion Mr. Paget removed nearly the whole of that bone. Since I have employed it, it has never failed to accomplish all that I require.

The india-rubber air-propeller I have rarely had occasion to use; but in a case where the instrument was employed by Professor Humphry in the removal of nearly the whole of the tongue, the patient resisted the vapour, breathing only through his mouth, until air was compressed through the instrument into his nostrils, when he was compelled to inhale the vapour. In operations under chloroform I always remove all teeth that are so

far decayed that they cannot be satisfactorily filled with gold. Previous to commencing, I mark with a lead pencil all the teeth I intend to remove, as when the mouth is full of blood it is difficult to see which the teeth are that require removal. Pieces of sponge on wooden handles are found useful in clearing the coagula from the mouth. In some cases, however, it is necessary to carry the degree of anæsthesia to that which I have called the end of the third stage—viz., where it is required to overcome muscular spasm, as in the reduction of dislocations, the extension of contracted limbs, &c. In cases that come more especially under our notice, we occasionally meet with some where rigidity of the muscles of the lower jaw arises from a diseased tooth. The mouth is sometimes so firmly closed that it requires the aid of chloroform to the above extent to enable the mouth to be opened sufficiently wide to remove the exciting cause. Such a case as the following is one in point :—

Elizabeth Tucker, *æt.* 11, a pale, unhealthy-looking child, with a somewhat idiotic expression, was sent to me by a surgeon to one of our large hospitals. She had been a healthy child up to eight years old, when she had scarlatina. In addition to some of the common sequelæ of this disease, she had numerous abscesses on various parts of the body, for which she had been in King's College Hospital. About a year after leaving this

hospital, she had pain in a first lower molar tooth on the left side, and from that time up to the period I first saw her there had been increasing difficulty in opening the mouth. The only movement she could make separated the teeth scarcely one-eighth of an inch apart. This patient was placed under chloroform, carried so far that muscular rigidity was overcome; and without much difficulty, with the aid of the mouth-opener I have described, I was enabled to remove the tooth. When I saw her a week afterwards she could open her mouth very well.

Before offering some remarks on local anæsthesia, it is perhaps right to say a few words upon the best means to be adopted should any alarming symptoms occur whilst operating with chloroform. Ordinary syncope is not uncommon, especially when much blood is lost. In such cases the horizontal position, or, what is still more effective, pressing the head down upon the knees, would in all probability suffice to restore the patient; but we must remember that the blood is charged with a very depressing agent, so we must excite as soon as possible the full action of the muscles of respiration, to get rid of it at the lungs, by dashing cold water on the face and chest, and moderately stimulating the mucous membrane of the nostrils, &c. It may be also advisable to administer stimulants: this should be done through the rectum, for fear of any getting into the trachea if

administered in the ordinary way. I have witnessed many cases of this accident, but have had only one case occurring in my own practice. My patient was a lady of about twenty-seven years of age, from whom it was necessary to remove every tooth she possessed. The gentleman who administered the chloroform was her relative—a physician of some eminence. She came to me about 12 o'clock in the day, having eaten very little breakfast. She was pale, apparently much alarmed, and her pulse was quick and feeble, on which account a little wine was given her. She took the chloroform well, which had to be applied two or three times, as she came round very rapidly. When all her teeth had been removed but six, her face suddenly became pale and her lips rather livid, her pulse became very feeble, and soon could not be felt. I applied a stethoscope over her heart, but could not hear it acting. The recumbent position was immediately adopted, fresh air admitted by the window, and cold water dashed on to the face and chest. This soon produced one or two sighing respirations, followed by return of the pulse and subsequent animation. On the same day the lady dined with her relative, and, under his advice, returned to me in the afternoon, when the six remaining teeth were removed under chloroform, which she took remarkably well. I may here state, that I think it best not to remove all a patient's teeth at one

operation, but rather to remove the teeth on one side of the mouth at a time, leaving the second operation until the side first operated on has pretty well healed up. This plan enables the patient to have one side of the mouth to eat upon. When they are all removed at once, I have found that the gums are often some time in healing up, and frequently do so only by granulations, which prevent the patient using a temporary set for some time.

To return to the subject of resuscitation. Should the means proposed—viz., the horizontal position, the admission of fresh air, the application of cold water, and introduction of brandy into the rectum—fail to restore animation, recourse must be had to artificial respiration. Should the accident occur when only one medical man is present, Marshall Hall's method is that most easily performed; but when there is plenty of assistance I should prefer the plan of placing the patient in the supine position, pressing upon the ribs and abdomen, and remove the pressure, about twenty times in a minute. It is an advantage to be able to watch the patient's countenance during this operation, and to see that air freely enters and is expelled from the lungs. Should it not do so, tracheotomy should be performed, as Dr. Marcet has recently shown that the chloroform in the system may produce spasmodic closure of the glottis. Of course, before doing so, the tongue

should be drawn forward, as this might, by falling back, have closed the glottis. I would myself keep up artificial respiration for an hour before giving up a case as hopeless. Galvanism has been found of little avail in these cases, and probably, from the time lost in employing it, worse than useless. If the veins of the neck and face appear much distended, an external jugular vein might be opened, but artificial respiration will usually soon relieve the right cavities of the heart.

Since the introduction of ether and chloroform, much attention has been directed to the truly important object of producing local anæsthesia. Dr. Arnott, in introducing a mixture of pounded ice, or snow, and salt to a part to be incised, or otherwise injured, has to some extent accomplished this object. The intense cold thus applied to a part causes contraction of the capillaries, and shuts off from the nerves their supply of blood, rendering them insensible to the impression of external agents. Mr. Walter Blundell, in conjunction with Messrs. Horne and Thornthwaite, of Newgate Street, invented an ingenious instrument for applying Dr. Arnott's principle in removing teeth, a description of which is to be found in an account of patents relating to Dentistry, given by Mr. Owen in the recent numbers of the "British Journal of Dental Science." The important part of their method of applying cold is in doing so

very gradually, and in not permitting the return of warmth suddenly. Notwithstanding every care that may be taken, the operation is frequently a painful one, and cases of sloughing of the gums and exfoliation of bone not very rare, one of which has come under my notice. Putting aside the length of time it occupies, the results given by those who have employed it are anything but satisfactory. I have seen cold used with most success when the surface of a part, as that of a cancroid ulcer, had to be destroyed by the action of liquid escharotics.

In the spring of the year 1858 I tried a number of experiments with electricity, my object then being to cause contraction of the capillaries by that agent, as is done by cold, and so by shutting off the supply of blood to the nerves of a part, render them insensible to impressions otherwise painful. Ill health, arising from overwork, prevented my continuing these experiments, and compelled me to leave town for some weeks. On my return, the daily papers were full of the accounts of the painless removal of teeth by electricity. So encouraging did the accounts of operations done in this way appear, and so satisfied did some of our patients express themselves with it, that its application in Dental Surgery seemed likely soon to become universal. Yet I apprehend but few practitioners now employ it to any extent. I rarely do so even for those

who previously believed they had been saved suffering by its application. In attempting to estimate the amount of pain a person feels in any operation, great allowances must be made for the nervous condition of the patient. Persuade your patient that an operation can be performed without his feeling pain, and you have done much to save him suffering; his attention is withdrawn to some extent from the sensations, and they are less acutely realized. On the other hand, we see how much an individual feels who has the mind strongly impressed with the idea that acute pain is impending. The exclamation which often precedes the application of the forceps to a tooth shows how the mind anticipates the coming pang. Electricity distracted to some extent the attention, which was engaged with the sensation it produced, so that the true sensation of pain was not so greatly appreciated. Persons often told me they felt as much pain, but they seemed better nerved to bear it. When it was employed, the operator experienced the advantage of having his patient in a good position, in which he was kept by muscular rigidity. In experimenting upon myself, I could never so far suppress pain with electricity as to enable me to remove one of my own teeth, which I found no difficulty in doing after a few inhalations of chloroform. Several substances, as ether and camphor, chloroform and camphor, &c., have lately been recommended as removing pain

in Dental operations when applied locally to the gums. Under my hands these bodies thus applied have not produced the desired results. When they have, I believe it has been chiefly due to several causes:—1, the effect on the mind, as just noticed; 2, some of the body getting into the circulation through the mucous membrane; and 3, some of the vapour of the chloroform or ether getting into the circulation through the lungs. I am very much in doubt as to whether the action of ether or chloroform on a nerve-fibre would have the effect of preventing its conducting impressions to the brain. Many of the remedies applied locally to alleviate pain do so by getting into the circulation, and so affecting the nervous centres. I have lately seen several cases where morphine has been injected into the subcutaneous tissue with this object; but it appears to make no difference at what part of the surface of the body it is injected, whether near or distant from the affected region. I have attempted to inject the gums with chloroform; but, although I employed the best-constructed syringes, failed, in consequence of this structure containing no loose cellular tissue. I do not deny that certain bodies, as aconite, &c., act locally upon the peripheral extremities of nerves; but I think Dr. Simpson is not far wrong in the statement, that "in the human subject the degree of partial or superficial anæsthesia which is capable of being produced by chloroform in the

state of liquid or vapour, is never sufficiently great to allow of the part being cut or operated upon without pain—at least not in man, probably in the lower animals."

The method of producing anæsthesia by pressing upon the nervous trunk supplying a part is, I think, not applicable in operations on the teeth.

GENERAL MONTHLY MEETING.

Monday, March 3, 1862.

JOHN TOMES, Esq., F.R.S., President, in the Chair.

The following Gentleman was duly elected a Member of the Society:—

Mr. S. Amos ..... Kirby, Huntingdon (non-resident).

The following Gentlemen were proposed for the Membership of the Society:—

Mr. Smollett W. Clerk, Madras, East Indies.
Mr. Alfred Jepson, 108, Warwick Street, Leamington.

The following Donations were made to the Society:—

By Mr. S. Cartwright, F.R.S.—Ten Volumes of the "Transactions of the Sydenham Society."

By Mr. Thomas A. Rogers.—A Series of the "London Medical Gazette."

By Mr. Edwin Saunders.—"The Teeth, a Test of Age."

By the Publishers.—The "London Medical Review."

Mr. Bridgman read a paper—

On the Absorption of Bone and Dentine.

Mr. President and Gentlemen,—In a lecture on mental education, delivered at the Royal Institution by Professor Faraday, it was observed, "that an essential precept, and one that should recur to the mind early in every new case, is *to*

know the conditions of the matter respecting which we are called upon to form a judgment;" and also, "that before we proceed to consider any question involving physical principles, we should set out with *clear ideas* of the naturally possible and impossible."

In treating of absorption, it is highly necessary that these suggestions should be kept in view; for although it may be a very convenient resource to which any particular uncomprehended proceeding may be assigned, when it comes to a consideration of the conditions involved, and the nature of the physical principles concerned in the process, it then becomes evident that there are many occurrences attributed to this cause which can in no way come within the range of *possibility*.

We profess to understand the manner in which fluids are taken up into the system, and to a certain extent we may be right in our supposition. But in reference to the removal of the more solid substances, such as bone and dentine, there are avowedly many points yet requiring to be explained.

In regard to these changes, in so far as they relate to bone, up to the period of Messrs. Tomes' and De Morgan's paper, read before the Royal Society in June, 1852, nothing whatever had been done towards clearing away the obscurity in which they were involved. In that paper some

very interesting and important features, which throw considerable light upon the manner in which they are effected, were pointed out and explained. These beautiful discoveries, however, have never yet been sufficiently appreciated, nor does it appear that any attempt has been hitherto made to connect them *as effects* with any cause which could govern or regulate their production.

It is one of the objects of the present paper to supply this deficiency, by endeavouring to show that the absorption of these substances is one of the results of the electro-voltaic mechanism of animal life; or, in other words, that it is strictly a part of the electro-biology of the system. But, in doing this, it will be expedient, first, to point out the relation between the electrical currents generated in the system, and some of those physical changes which we are accustomed to regard as the effective and sustaining powers of the organism; for, by thus making it clear that these changes are identical with the results which can be obtained in the laboratory by the Chemist and the Electrotypist, it will then be less difficult to show that the absorption of bone and dentine are as much a part of this same law as the absorbing of nourishing material is a part of the growth of the body.

In the case of an organized being, every portion, at some previous time, has existed in a fluid state.

With regard to ourselves, every atom of the living body has been consolidated out of materials derived from the liquor sanguinis of the blood. And as those portions which require renewal, such as particles of bone and worn-out muscles, have to be absorbed and carried away in the same channel, it is self-evident that, before any such solid substances can be so disposed of, they must first be reduced either to a liquid again, or be separated into their elements in a gaseous form. Both these conditions are respectively attained. Of the latter we have evidence in the exhalation of carbonic acid from the lungs. The production and disposal of this element constitutes one of the most interesting and important features, so far as the welfare of the individual is concerned, to be found in the whole range of absorption. Animal tissues consist of about one half carbon, and as all muscular action is supposed to arise from the decomposition of muscular fibre, the chemical destruction of the latter substance is presumed to be the source from whence it is derived. But as every muscular movement requires the contraction of particular individual muscles, and these special muscles require to be thrown into action while the opposing ones remain passive, one link of the chain is indicated as being absent. If we stretch out an arm, the contraction of the muscles placing it in the position required is the response to the will. But to enable the act to conform to the will or inten-

tion, there must be some other power brought into play to connect the particular muscles with the desired movement. Chemical action may set free the force which accomplishes the motion, but there must be some means of exciting this chemical action in the right muscles and at the proper instant — some special agent whereby the order may be sent instantaneously to its right destination.

In the recently expired subject we see this effected by the electro-voltaic current. And as similar currents have been proved to exist in the living subject, we may safely assume a similarity of action to result. On this point, Mr. Alfred Smee, in his Electro-Biology, after describing an experiment upon the cheek of a rabbit, says: — "The deflection of the needle in the electro-voltaic circuit proved the existence of a voltaic current passing through the parts during the action of biting, and did," says the author, "thus denote the mechanism of the force employed to throw the muscles into operation." So far, then, we have conclusive evidence that muscular contraction is accompanied by an electric current; but these currents in the system will henceforth be spoken of as electro-*vital*, in contradistinction to the electro-*voltaic* currents of the battery to which they are analogous.

The ordinary action of an electro-voltaic current is to produce chemical decomposition, and

Professor Faraday states that "chemical action is sometimes a more delicate test of electrical currents than the galvanometer." Therefore, as all parts of the system contain water more or less charged with organic matter, together with an abundance of inorganic salts, we can no more have an electrical current passing through these bodies *without effecting their decomposition* than we can have rain without water, or hail and snow without ice.

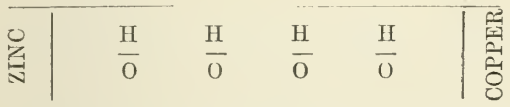
To render intelligible the manner in which the elements of this decomposition are absorbed and disposed of, recourse will have to be made to the conditions which constitute a galvanic series, and the mode of interchange which takes place among the elements of an ordinary battery. This proceeding will be required also to afford an explanation of the laws of electro-deposit and solution, corresponding with growth and absorption in the system, as well as the transference and decomposition of earthy salts, as taking place in the calcifying and decalcification of the bones and dentine.

The Galvanic Battery.—To constitute a galvanic arrangement, three elements are requisite.

Two of these require to be substances of different affinities for oxygen, and the third a liquid capable of being decomposed, so as to furnish the necessary oxygen.

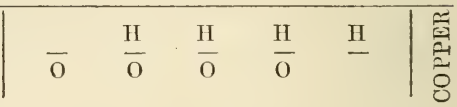
If a few inches of copper wire, bent into the

form of a horseshoe, have its two ends dipped into dilute sulphuric acid, it will produce no perceptible effect. But if, by hammering, by heating, or by any other means, one end can be made to exhibit a greater affinity for oxygen than the other, then we shall obtain a very different result. It will produce a galvanic action. If it be in a liquid capable of dissolving the oxide thus formed, one end will continue to dissolve until either it or the solvent becomes exhausted. We have had a good illustration of this action in the aluminium formerly tried as plates for artificial dentures—hammering or biting upon rendering the part rapidly soluble in the fluids of the mouth. The same action is one of the prevailing epidemics of our iron ships. But if we substitute a piece of zinc for the hammered end of the wire, we get a far more effective combination. Zinc with copper or platinized silver form the battery in common use.

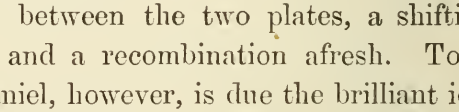


If we take the above diagram to represent the zinc and copper plates, and $\frac{H}{O}$ the elements of the intermediate water, with the connecting wires above, the instant these connecting lines are brought into contact, a remarkable change takes

place in the whole circuit. The result will be this:—



One equivalent of the water has given up its oxygen to the zinc, and the odd equivalent of hydrogen appears at the surface of the copper. To acquire this position, there must have been an instantaneous separation of all the elements of the water between the two plates, a shifting of partners, and a recombination afresh. To Professor Daniel, however, is due the brilliant idea of improving upon the preceding arrangement, by obtaining the *absorption* of the hydrogen at the negative pole of the battery, as fast as the oxygen was being consumed at the positive, thus enor-



mously increasing the rapidity of the action. It was accomplished by inclosing the copper plate of the battery in a membranous bag filled with a solution of sulphate of copper. The oxide of copper held in solution was decomposed, giving up its oxygen to combine with the free hydrogen, whilst the metallic copper was left in its pure state upon the surface of the copper plate. Herein we have the original discovery of the

electrotype, the principle of electro-depositing, which, to the physiologist, forms a subject of especial interest, because it furnishes a key to the correct reading of many of the operations carried on in organic life, as well as to some of those morbid and disorganizing conditions which without it have been most puzzling and inexplicable, while at the same time it affords an indication of the principles upon which their correction must be sought for.

If, instead, as in the previous arrangement, of joining the two connecting wires direct, their ends be made to dip into a second vessel, containing a conducting liquid (as in Fig. 4), we get a secondary or precipitating cell, in this second vessel we shall also have decomposition effected. It is also to this secondary cell that our future remarks will apply, as well as with which the experiments to be mentioned have been conducted in the ordinary form of battery.

Decomposition of Animal Matter, and Absorption of its Products.—If albumen or an albuminous substance be made to undergo chemical decomposition, we shall have, in addition to oxygen and hydrogen, as in the former experiment, a small portion of nitrogen, and about one-half of the weight when dried as carbon, or charcoal. We have before noticed that, in decay of the teeth, it is this carbon which produces the dark stains. It is also to be seen in the pigment-cells of bron-

chitis, its passage from the blood to the oxygen of the air, in the air-passages, being impeded by the inspissated mucus lining the tubes. But if carbon in this state be again burned with a further supply of oxygen, it becomes converted into carbonic acid gas. In the system, the supply of oxygen for this purpose is, as we all know, one of the results of breathing, the carrying process being effected through the medium of the blood. The transference of the elements, however, is as purely due to electrical agency as is the separation of the oxygen from the hydrogen in the voltaic battery. The bright globules of arterial blood are stated to contain *peroxide of iron*, that is, iron combined with one proportion and a half of oxygen. In passing through the capillaries, this brilliancy of colour is superseded by a dull liver colour, owing, it is believed, to the peroxide of iron having been converted, first, into a *protoxide*, and then into a *proto-carbonate*.

In the preceding diagram it was shown that, on the contact of the wires being made, a rearrangement of the elements takes place in a different combination, owing to a fresh attraction having been introduced. The zinc has a greater affinity for the oxygen than the hydrogen has, and consequently it has taken it away from the hydrogen to form oxide of zinc.

Of this action there are two theories extant, the "contact" theory, and the "chemical"

theory. Neither, however, gives entire satisfaction, although the latter is the more generally received. But if we substitute another term, namely, that of "affinity," the mind is at once led to embrace the idea of the conditions and interchanges which are inseparable from them as results. To apply this law of affinity to our present subject, we have only to suppose that the electro-vital current, accompanying or causing the contraction of the muscles (whether voluntary or involuntary), at the same time that it effects the decomposition of the muscular fibre, must necessarily produce also the same effect upon all the albuminous and other compounds within its circuit or influence. Thus the albumen of the blood and the colouring matter of its globules come in for their share in the separation and recombination of elements consequent upon the liberation and reconstruction of matter upon the new scale of affinities. In consequence of all muscular fibre being supplied with arterial blood in its immediate neighbourhood, there is thus always a good supply of oxygen on the spot where decomposition will have set at liberty the carbon of the albuminous material; and as the oxygen is, equally with the carbon, under the influence of separation and rearrangement, the affinity leads to their combining as carbonic acid, and their subsequent union with the iron as a proto-carbonate, in which state it is hurried off to the lungs for ejec-

tion. But there must be another electro-vital decomposition to effect its liberation from the iron of the blood before it can be exhaled; for the latter would never yield it up again, unless there were some stronger affinity to upset its attraction, and leave it free to escape. There is but one solution for this proceeding. The air taken into the lungs consists of *oxygen* and *nitrogen*. The affinity of these for each other is *less* than the attraction of *iron* for *oxygen*. Hence, on the liberation of the elements, the *iron* takes the *oxygen* as a *peroxide* again. The attraction of the *carbon* for *oxygen* is then *stronger* than the affinity of the *oxygen* for the *nitrogen*, and consequently it passes to the oxygen of the air, again forming carbonic acid, and escapes with the nitrogen at the next exhalation.

The carbon being got rid of in this manner, the other products unite, forming various compounds. But as the union of the hydrogen with the oxygen results in forming water, and which in the Daniell's battery causes the membranous bag to become filled and overflow, is, in the system, provided for in a special manner. The blood-vessels are supposed both to imbibe as well as transude fluids; and if this additional portion of water had to be taken in at irregular intervals, and in different localities, and thus become only imperfectly mixed with the blood, it would materially interfere with its right condition, by altering its density by places.

Hence we have a separate set of vessels, the lymphatics, to carry away just so much of the superabundant moisture as would, by too much diluting the blood, become injurious, off into the thoracic duct, to join the current in its return journey.

The idea generally prevailing has been, that the *lymphatics* (or *absorbents*, as they are more commonly called), in the removal of bone and dentine, do the principal work of absorption. There has been no proof whatever obtained that this is really the case; all the evidence bearing upon the subject tends rather to strengthen a contrary opinion, and to show that it is mainly performed by the blood-vessels themselves,—a belief which is borne out, if not fully confirmed, by the facts about to be mentioned.

We have yet spoken only of the material undergoing chemical decomposition previous to being absorbed. We come now to the absorption of material *not undergoing decomposition*. This becomes, with soft substances, a mere question of solution and imbition; but in the case of bone and dentine, it is evident that some change must be effected previously, to reduce it to a condition capable of being dissolved. This is accomplished by effecting its decalcification. The hardening element is first removed, so as to reduce the structure to its primitive cartilaginous condition; and although the two processes, the decalcification of the bone, and the solution or conversion of the

cartilage, may go on so closely together as to appear but one, there are cases frequently to be met with which show the one far in advance of the other; and intermediate stages may be traced connecting the two extremes, so as to prove it to be the order of procedure. In this respect, it is simply a reversal of the stages of formation. In being formed, bone cartilage first, and rendered hard subsequently. In absorption, decalcified first, and the bone cartilage removed afterwards, Mr. Rainey argues for the introduction of the lime being a physical and not a vital effect. That it is not only a physical but an electrical arrangement, will be strongly confirmed by the following experiment: — Take a small piece of amber, or a thin strip of hardened vulcanite, and having warmed it by friction on the palm of the hand, or on a piece of woollen cloth, rasp it over a tumbler of tepid water. The particles falling upon its surface will arrange themselves in strings and circles, much in the same way that Mr. Rainey has figured at pages 118 and 119 of his book.

The manner in which these fragments comport themselves is a clear indication of their electro-polar condition, and will be seen to be very distinct from capillary attraction. But it must be distinctly understood, that in all these experiments no attempt at interference with the architectural design of an organized fabric is intended, but simply a mere exhibition of the *agency* employed in

constructing and arranging the materials made use of.

Decalcification.—With respect to the *removal* of the hardening element, there can be little question of *electrical* influence, seeing that no other known agency can be found to effect its removal in a similar way, under the same circumstances. If a piece of sulphate of lime (or any other insoluble salt) be placed in water under the wires of a galvanic battery, it will be decomposed. The lime will appear at one of the wires, and the sulphuric acid at the other. If we now reverse the current, by changing the connection of the wires with the battery, the action will be reversed too. The lime will again leave the wire it had first gone to, and reappear at the opposite one; the sulphuric acid doing the same. But if the wires be dipped into a solution of sulphate of copper, as in fig. 4, a deposit of pure copper will form instead of the lime, and the other wire will be dissolved. These conditions will equally change places on the wires being reversed; and this reversal of the current causing the thick and thin ends of the wire to change places, *constitutes the key to the alternate or reciprocating action of growth and absorption* in the system.

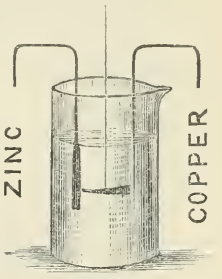


FIG. 4.

Precipitating cell of battery, showing increase and absorption, with an intervening wire rendered polar by induction.

It has been shown by Messrs. Tomes and De Morgan, in the paper before alluded to, that a similar and corresponding action to the preceding is continually going on in the bones during life. In a transverse section of a long bone, between the central or medullary cavity and the exterior surface, there are numbers of rings, with an opening near to the centre of each, known as the "Haversian *systems*." These central openings, which are termed the "Haversian *canals*," are traversed by blood-vessels, and are in one of three states.

They are either growing, and thus become less in diameter by the formation of new rings of bone to the inner side of the opening (as at A, Fig. 5).

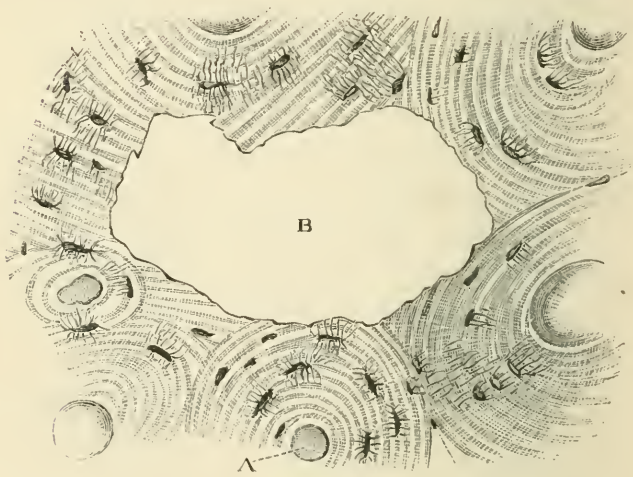


FIG. 5.

Transverse section of compact bone, showing the Haversian space, with its characteristic emarginated outline. A. Haversian canal. B. Haversian space.

Or they are being absorbed and becoming larger. In this state they exhibit a *sharp* and *irregular* outline (as at B, Fig. 5), and are then by the authors named "Haversian *spaces*." After they have enlarged to a considerable extent their further enlargement ceases, and new systems of rings commence to be formed within them (as at A, Fig. 6).

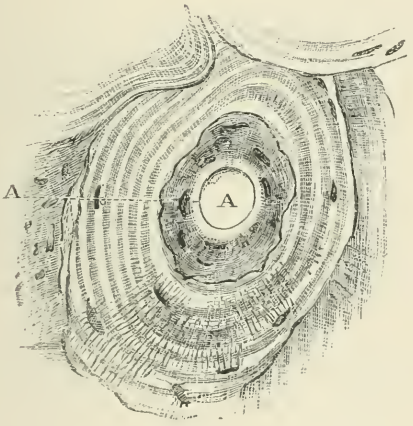


FIG. 6.

Section showing the characters of a new Haversian system developed within an older one. A. *Space with new system within it.*

Or they may present both conditions in one opening: one side being in an absorbing or wasting condition (as at A, Fig. 7), while on the opposite side new material is being added for the formation of a new system (as at B of the same Figure).

"This is a very important fact, as it demonstrates that the old tissue is removed in masses,

and a new one developed in its place. It has long been taught," say the authors, "that the older particles of an internal tissue are removed by absorption, and new ones substituted, and this throughout the life of the individual. But the authors believe that they have demonstrated it for the first time."

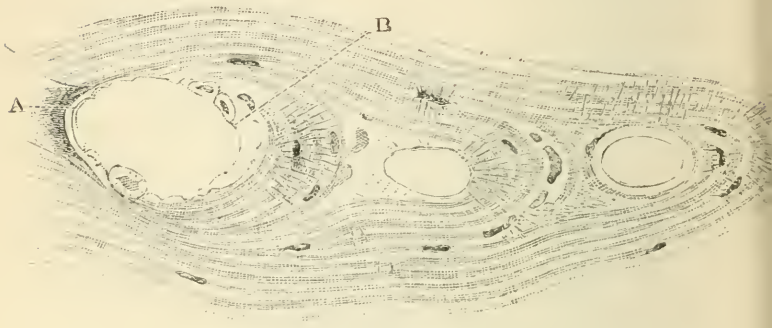


Fig. 7.

Section showing the two actions going on in one system. A. *The part absorbing forming a space.* B. *New growth, lessening the cavity on the opposite side.*—(From Messrs. Tomes and De Morgan's Paper.)

Two of these conditions, the growing and wasting surfaces, are fairly represented by the two wires from the battery in the precipitating cell; but there is this slight difference, that as the *external* surface of a wire is being absorbed, the diameter is lessened, while absorption from the inner surface of a tube increases its diameter, thus reversing the result while the action is similar.

With respect to the third condition in which both the absorbing and growing processes are going on in the same opening, there is one other

electrical phenomenon now to be noticed which is perfectly parallel with this proceeding. It is this. If a small piece of wire be suspended in a fluid between the two wires from the battery, when an electrical current is passing and electro-depositing going on, it will become *electro-polar* by *induction;* that is, without touching either of the other wires, it will receive an electrical condition, and one end will become positive and the other negative. It will also partake of the same electrical action that is going on in the poles of the battery, by having one end dissolved and the other increased by fresh matter added to it, thus forming an *isolated* "growing and absorbing" mass. The action is not confined to a single individual, but every other isolated mass so situate may partake of the same action. Each wire becoming polar by induction has its poles presented to the contrary poles of battery, and if the current be reversed, the thick and thin ends change places respectively.

If we refer to a figure of a *longitudinal* section of a long bone, as given in plate xvi, vol. ii, of the "Histological Catalogue" of the College Museum (or Fig. 8), it will be seen that the Haversian canals and spaces run parallel, or nearly so, and occasionally anastomose with each other. If a *canal* be in a negative or growing state, and an adjoining *space* be in a positive or wasting state, they will give us the two conditions of the battery wires in our former experiment; and a third

canal or space branching in between them becomes precisely in the condition of our induced current, and will thus necessarily be in both states; one side of the opening will waste, and the other will receive an addition of new substance.

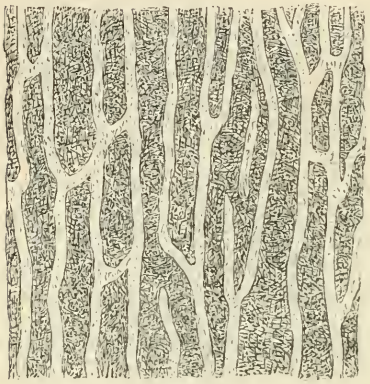


Fig. 8.

Vertical section of the femur of an adult human subject, showing the course of the Haversian canals.—(Histological Catalogue.)

To set up absorption, therefore, in a bone which is negative, it is only necessary to induce an electro-positive condition of the part.

Where the conditions are so nearly balanced as they are in organic life these changes of polarity are continually occurring. On this point Dr. Carpenter observes, that "it has been made apparent that there are no two parts of the body which have their electrical condition precisely the same, and that it has been found that the skin and most of the internal membranes are in opposite electrical states, and that it seems unquestionable that every integral particle of the muscular substance must be a centre of electro-motor action, and must contain within itself positive and negative elements; and the *variations both of*

intensity and direction in the muscular current, under certain circumstances, *are so sudden and so extensive*," &c. And again, "that heat applied near a nerve will alter the direction of the current."

We have thus the most unquestionable authority for the existence of the currents, and their frequent change of direction; and it now remains to point out their electro-chemical action in effecting absorption of bone and dentine.

An electro-*positive* condition being set up on a surface of bone must necessarily lead to the electrolytic removal of its lime. In the absorption of bone it is invariably the first stage in the proceeding, and is an important fact, and one of great value, but I have not been able to find that it has ever before been pointed out. There is, placed before you, a deciduous tooth, in which a small excavation has been made on its side, leaving the decalcified tissue almost unchanged. Arranged by its side is a piece of dentine in which a similar excavation has been made *artificially*—by electro-voltaic agency. On the spot where the *positive* pole of the battery rested, a small pit has been formed in its polished surface, and a short piece of the wire, which formed the negative pole of the battery, is also here, *having on its surface the lime which was removed from the preceding decalcified spot at the other end of the battery.* We thus get a perfect identity of result so far.

Artificial Formation of Substance resembling Bone. —If, however, instead of placing the dentine in water, as before, we now substitute albumen, or white of egg, we shall get a very different set of results.

The instant the wires are immersed they become coated with a white froth, which gradually increases until the two masses meet. Shortly afterwards, *a third portion spreads out between them, right and left, or at right angles to the two poles.* After the battery has been in action some ten or twenty hours, it will mostly be found that a gelatinous mass has spread out under the positive pole, and which, from its acting as a conductor, has diffused the decalcifying effect, and caused a much larger space to be acted upon; *but the line facing the negative pole will invariably be sharp and distinct.* Around the negative pole will be found a large mass of brilliantly clear and transparent jelly. This substance, although it has been formed out of albumen only, *is entirely altered in its character.* It is no longer like albumen, soluble in cold water, or coagulable by heat. It has become identical with the material of basement membrane, and bone cartilage. There is a portion on a glass slide in its primitive state, and also two small pieces which were cut from it and boiled for half an hour, thus showing them to be perfectly insoluble by boiling.

The portion formed at right angles to the two

poles is of this character in its densest state, almost, if not quite equalling the densest cartilage. An examination by the microscope shows that it is *also in some parts thickly studded with peculiar globular crystals of lime, closely resembling those figured by Mr. Rainey.* It is thus, in its composition, strictly analogous to bone in the early stage of its calcification. Under the microscope it presents much the same appearance as the figure given by Mr. Rainey of "the innermost layer of the shell of a very young lobster," at p. 81.

There is also a specimen with this substance *in situ* just as it is formed. It is firmly attached to the surface of the dentine and closely adjoining the line of demarcation between the two conditions of polarity.

Bone itself has a laminar structure. Messrs. Tomes and De Morgan, in speaking of the *laminæ of bone*, remark that "when lamination reaches its highest degree of development, each lamina is seen to be made up of two parts,—an outer, which is highly granular, composed oftentimes of a single line of large granules or cells; and an inner portion, which is singularly clear and transparent, and to all appearance without granulation or any recognizable structure." In our *artificial bone* there is precisely this same arrangement of a clear and transparent layer with another layer of the globular crystals attached to it. The layer of earthy matter forms at the surface nearest to the

positive pole, and the clear one at the negative pole, but within this there is also a peculiar cell-like appearance.* In these experiments, then, we get, first, the decalcification of the dentine at one pole; next, the formation of cartilage at the other; and subsequently the introduction of the lime into its outer layer. We thus have absorption and reproduction going on simultaneously, and precisely as Messrs. Tomes and De Morgan have shown us to be taking place in nature, so that we can scarcely hesitate to accept the fact of electricity being the agent employed in both cases.

The basement tissue left after decalcification then remains for disposal. This may be accomplished either by the introduction of new vessels into it, and its appropriation as new tissue, or, in the absence of these, it may assume a morbid condition, and ulceration or suppuration follow.

Ulceration has always ranked as one of the diseases "*of Bone*." This, however, is not strictly correct. We may have ulceration "*in the bones*" or "*in a bone*," but not "of" or "in" bone itself. *Before ulceration can take place, the part will have*

* In Nasmyth's "Researches on the Teeth," page 133, Fig. 24 presents a remarkable resemblance to the appearance of this substance. "On examining the internal structure of the pulp generally," says the author, "the number of minute cells presenting themselves in a vesicular form is very remarkable; they seem to constitute, indeed, the principal portion of its bulk. These vesicles vary in size, from the smallest perceptible microscopic appearance, probably the ten-thousandth part of an inch in diameter, to one-eighth of an inch, and are evidently disposed in different layers throughout the body of the pulp.

ceased to be "Bone." It will have become simply "basement tissue" or "bone cartilage," — the organic basis of Bone. We have the death, or necrosis of bone and its exfoliation *as bone*, but in ulceration the first change must necessarily be, and invariably is, the electrolytic removal of the lime, or a portion of it. The decalcified tissue is then in a condition extremely prone to become ulcerated. This distinction is important, as it points to the source of the extension of an ulcer, and also to the fact that by altering the electro-polar condition of the part so as to stop the removal of the lime, the ulceration, being only a secondary effect, when it reached the bone, would die out for want of further material to feed upon.

Absorption of the deciduous Teeth.—Absorption having been found to take place in the Haversian canals of bone, it might, hence, be expected that the like function would be performed by the contents of the "cavitas pulpæ" of the tooth; but as it is known *not* to be so, this fact at once stamps a conclusive negative on the supposed analogy between them, and shows that the comparison cannot be substantiated. In absorption of the teeth, the apex of the fang being the part last formed, is also the part first to become acted upon. If the extreme end of the socket of a single-fanged tooth be closely examined, it will be seen that, besides the one large foramen for the passage of the nerve, &c., to the pulp, there are many other

smaller ones congregated around it. These are for the passage of the principal vessels from the cancelli to the vessels of the periosteum and peridental membrane, and it is here that the first signs of absorption are to be met with. On the removal of a permanent tooth for an attack of peridentitis, it may be observed, almost invariably, that these vessels on the apex of the fang are the first to become inflamed; and if we examine a socket in which absorption has taken place, the foramina, or apertures in the walls of the internal plate of the alveolus admitting these vessels, will be seen to have become enlarged, and presenting all the appearance of having been bathed in a fluid capable of dissolving the bone, and thus producing their enlargement. There is a portion of an adult jaw which shows this condition fully. (Fig. 9.)

Fig. 9.

Portion of an adult jaw, showing the effect of absorption at a, in the vessels at the apex of the fang.

There can be no question but that the vessels thus forming the medium of the absorption of these passages would also have their action continued on into the peridental membrane, and so constitute the agents in the absorption of the tooth.

When the crown of an absorbing deciduous tooth has dropped off or been removed, the surface of the gum beneath it soon returns to its

original state. This portion of the gum begins to form at the apex of the fang when absorption commences, and as absorption proceeds, the conversion of the decalcified tissue of both the fang and the socket keeps pace with it, until its primitive condition be again reached.

The progress of an absorbing tooth may be marked by one of several peculiarities. It may be normal, or abnormal; it may be healthy, or unhealthy.

In its *normal* state, it will proceed uniformly until the edge of the enamel be reached and the shell drop off.

In its *abnormal* state, it will stop short of this, and one or more parts of the fang be left unabsorbed.

In its *healthy* state, the decalcification of the dentine and the conversion of the tissue will proceed uniformly, and with but little or no excess of vascularity arising.

In its *unhealthy* state, the decalcified tissue may become rapidly tenanted by new vessels, and excessive vascularity arising may lead to inflammatory stasis and suppuration. Or, the decalcified tissue may remain unappropriated, and give rise to a series of morbid conditions. One of these states has been well described by Mr. Shelley, in the first volume of the Transactions of this Society. The decalcified tissue, as the author observes, is "soft, almost diffluent on the surface;

in the middle it is somewhat denser, and at its union with the fang it is of a gristly cartilaginous texture." Under the microscope, the soft mass seems to consist almost wholly of granular and nucleated cells. Near the unchanged dentine is a portion "seen to be fibrous tissue in a state of formation." At its junction with the fang the substance becomes dense, and is torn with difficulty, but in which the wavy appearance of fibrous tissue may still be distinguished. This description reads beautifully clear and distinct when we put the previous interpretation upon the facts which it contains, and is an admirable illustration of the commencement of ulceration taking place in the decalcified and softened tissue, as previously alluded to.

In the absorption of the deciduous molars, the proceeding differs slightly from that of the incisors and cuspids.

Between each single-fanged tooth, the septum has on its edge a number of the minute foramina for the passage of the vessels from the inner cancellous tissue to the gum above it. Each molar tooth has one of these septa in the division of its fangs, and the vessels in this part act simultaneously with the vessels at the apex of the fang, or, if not at commencing, will soon afterwards take up the action, and thus absorption will be going on from several points at the same time. The fact of absorption of the fangs of deciduous

teeth taking place on the side nearest to the growing tooth, would naturally give rise to the belief that the new tooth beneath it must be concerned in the process, and, hence, we have the idea that the so-called "enamel organ" becomes the "absorbing organ." This enamel organ, however, is purely a myth. There is no more evidence of an enamel organ than there is of a "dentine organ," or a "bone organ." In my former paper on caries, it was pointed out that the formation of the enamel could arise in no other way than from an altered secretion, during an alteration of condition and circumstances specially ordained for the occasion,—the part being restored to its original state after this special duty has been performed. The supposed enamel organ is but the capsule of the growing tooth, a portion of the gum reflected into the crypt, and forming the lining membrane of the cavity. The capsule of the permanent tooth is identical with the capsule of the temporary tooth in this respect, both arising out of a duplicature of the gum.

The socket of the permanent tooth is also but a pouch formed out of the lingual plate of the alveolus of the temporary tooth above it and the gum reflected over its inner surface entering by the foramen of the "gubernaculum."

In the bicuspides this filament is stated to be connected with the *periosteum of the milk molars.*

It can scarcely be supposed that so great a departure from an ordinary principle would be resorted to where no possible advantage could accrue from it. If we turn to the incisors we find the entrance for the " gubernaculum " unmistakeably distinct from the neck of the tooth above it, but as clearly belonging to the *gum*. In the cuspid, this foramen opens some way down the inside of the socket, *but as it is continued up to its edge by a groove*, we may safely conclude that its union with the gum was intended, for if merely to join with the periosteum, there would have been no need for the groove, as it would have united the periosteum at once. In the milk molars of the *lower* jaws there is no obstruction offered by the tooth embracing the septum, but in the upper the palatal fang would obviously be in the way; and, therefore, we find that this fang is placed obliquely, and there is thus a greater obliquity given to one of its sides to allow of this part not being interfered with—apparently on purpose to make room for it. We find, further, that when absorption has led to a junction of the periosteum of the old tooth with the crypt of the new tooth, the gubernaculum becomes obliterated, showing that by its junction with the vessels below it, its union with the upper surface becomes no longer necessary.

In illustration of the fact, that the vessels of the crypt of the new tooth are not concerned in

absorbing the alveolus and fang of the deciduous tooth, I have procured specimens—portions of an immature jaw (Figs. 10 and 11)—which show the walls of the crypt with the foramina in their minute and perfect state, while the foramina of the alveolus of the milk tooth immediately over it are very much enlarged, and clearly showing the direct communication of the latter with the cancelli, independently of any connection with the vessels of the new tooth or its appendages.

Fig. 10.

Fig. 11.

Portions of an immature jaw, showing the upper wall of the crypt c, of the new tooth, with the absorbing condition of the temporary alveolus, a, above it, and the separation of the two by the cancellous tissue.

Viewing the question altogether as one of electrical agency, every difficulty is at once overcome. In the absorbing tooth and the growing tooth beneath it, we have the opposite conditions of the two states of electric polarity,—the crypt with its new tooth in a negative state, and the deciduous tooth in a positive state. We have the foramina for the passage of the vessels to each through the alveolus in a corresponding condition. In the one they are minute and perfect, in the other enlarged and rounded away by solution; both showing, by these features, their connection

with the part to which they respectively belong. The two actions of growth and absorption are thus, as in the experiment with albumen, taking place in immediate contiguity, yet perfectly distinct. And hence it is that the surface of the fang presented to the growing tooth is the part first to be absorbed. This is not always confined to the crypt corresponding with the tooth in question, but may also arise from the opposition of a neighbouring crypt. We have an illustration of this in an upper molar, on the distal surface of the posterior fang of which is a portion so acted upon.

In electro-depositing, where one surface is dissolved and the other increased, the loss of the one and the gain of the other are not necessarily equal. The difference is made up by the solution becoming either weaker or stronger, according as either action may predominate.

This fact is illustrated in the following experiment. At the conclusion of the experiment in the production of cartilage and the decalcification of dentine, the latter was taken out, and a piece of glass substituted in its place. There could be no more lime thus added to the solution; and to show that a portion of the lime dissolved out of the dentine in the previous case remained in the albumen, the battery was again set to work. After an interval of about twenty hours the glass was taken out, drained, and dried. There were

the indurated cartilaginous mass at one pole, and a smaller mass at the other, but between them there was also a thin film, densely studded with the globular lime, as in the former instance. The lime was here furnished from the solution, while no absorption was going on to replace it, thus corresponding in action with the growth of the new tooth continuing, where absorption of the old one had become interrupted, showing that they are not necessary to each other, although both are dependent upon the same influence.

In this respect the action is identical with the absorption and reproduction taking place in the bones, and the growing tooth and the absorbing tooth are to each other in the same relationship as the Haversian canals are to the Haversian spaces.

The introduction of an ivory peg inserted to set up new growth in a fractured bone, is a perfect example of electro-vital excitation, and can be reasonably defended upon no other principle. The presence of a fresh element disturbs the balance of affinities in the part: while this fresh element itself, becoming dissolved, proves its condition, in relation to the surrounding tissues, to have been electro-positive, and its being electro-positive implies the existence of a negative pole near to it. An electro-negative condition in electro-depositing is synonymous with increase; thus, the end of the bone being restored from a passive to an active state, the vessels, in conse-

quence, proceed to repair the injury by a deposit of cartilage and its subsequent calcification.

Cell-structure.—In connection with an absorbing surface cell-structure is mostly present. I think we must regard the appearance of cells, under these circumstances, as *a consequence* of the same action that is causing the other changes, and as only ministering to the alteration of structure taking place through the basement tissue being converted into the fibrous tissue of the papilla, which is forming out of the decalcified dentine of the tooth above it. It is a perfectly analogous condition to the present, under which the cell appearance has been produced artificially; and there is therefore reason to believe that their immediate action in producing the pitted surface of an absorbing bone arises from their fluid contents forming a better conducting medium than the tissue, and thus causing each cell to act like the end of the wire from the battery upon the piece of dentine before us; that is, to become a separate centre of action, and so to produce its corresponding excavation. We have a somewhat analogous effect in the better conducting power of water over albumen, in our previous experiment; the water suffering the lime to pass to the opposite pole, while the albumen checked its passage, and caused it to become crystallized almost immediately over the spot from whence it was taken.

The general impression, hitherto, seems to have

been that absorption is mainly, if not wholly, due to the action of the absorbents ; and it is also believed by some that the blood-vessels do not imbibe as well as transude. The rationale of electrical action will show us that both these are most probably erroneous. The membrane in the Daniel's battery proves that this intervening substance is no impediment to the passage of an electrical current, and further that it is necessary for separating two fluids in which contrary actions are taking place. In fact, when albumen is being acted upon electro-voltaically, a substance analogous to this membrane becomes formed by the action of the electricity so as to constitute an intervening diaphragm dividing the contents of the vessel into two portions, which latter then also assume a difference in their chemical character. The membranes composing the coats of the blood-vessels are so constructed as to be permeable in both directions, there is no obstacle to the passage either way; and as the transudation of the albuminous fluid of the blood would not arise spontaneously, or be given out indiscriminately,—that is, without some controlling agent to direct the supply where vital action was rendering its presence required,—this, like the movement of the blood-globules, would indicate its dependency upon some power of supervision and guidance, and that some connection existed between the cause of want and supply. In electrical action we have

seen the same conditions existing. Hence, if we take an Haversian space where the walls of the opening are being removed, this electro-positive condition implies the receiving condition of the central *contents* of the space. If there be no absorbents here, as would appear to be the case, the blood-vessels must necessarily receive it into themselves, and *vice versâ*—that is, when an Haversian canal is filling up—would furnish the albumen for the tissue and the lime to harden it.

We have no evidence of any greater amount of absorption taking place in the pulp of a tooth than may lead to its becoming smaller and denser in its texture. But it is well known that the formation of new dentine continues to be formed up to a late period of the tooth's existence, proving the retention of the same condition, and some portion of its original power of formation. That this should be so, is due to its character and position in relation to the surrounding tissues; and in the deciduous tooth the head of the pulp does not partake of the absorbing action until the external vessels have reached its level: then its capillaries take up the action, and the crown of the tooth is gradually emptied of its bony contents until only the enamel is left.

The absorbing part of a tooth frequently presents the appearance of fine vessels ramifying over its surface. Now, as no vessels of this kind exist in the dentine, these must have been formed

during the action and have sprung up in the remaining thin layer externally of the decalcified tissue, a part which has thus become a "periosteum" or "peridental layer" for the time being. The periosteum being styled a *membrane* gives a false idea of its real character. "Periosteal" or "peridental" *layer* is a much more correct term. As in the instance just named, the outer layer of all osseous fabrics is a part *without the hardening element*, which is appropriated by the capillaries, and thus becomes the Periosteum. Viewing a tooth, or a bone *in its perfect state*, the external layer very fairly resembles "a membrane" spread over its surface, but on taking it to pieces and tracing its construction or building up, its true character and relationship cannot fail to be recognized. The pattern of the vessels in the periosteum (as shown in fig. 12) will be seen to be a miniature representation of the section, showing the Haversian canals in fig. 6, and on the increase of substance by fresh layers externally, the smaller are ready to become merged into their larger companions. The periosteal layer is thus, in reality, an outcropping portion of the substance of

FIG. 12.

Blood-vessels of the periosteum.—(Histological Catalogue.)

the bone itself, and it is in consequence of this, and a continuation of this substance forming the tendons of the muscles, that the latter have so much strength in their attachment to the bones. It is also from the appropriation of this substance by new vessels through the capillaries extending into it, that a new periosteum is able to be formed under an exfoliated surface. New bone having been found to be produced by *transplanted* portions of periosteum, we cannot suppose the tissue itself to have any other office than as a nidus for its vessels; therefore we must conclude that the capillaries contained within it are the real agents in doing the work.

Seeing, then, that we can get no absorption where there are neither red globules, nor vessels for the circulation of fluids (and that where this does take place, their traces are visible to the eye), and as neither are to be found on the external surface of the crown of the teeth, it would seem, that for the polished notches at the necks of the teeth, the wasting edges or faces of the anterior portions of the denture, or in fact for any portion of the *crown* of the tooth, to be removed by the organ itself, must be classed with the "impossible."

GENERAL MONTHLY MEETING.

Monday, April 7, 1862.

JOHN TOMES, Esq., F.R.S., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

J. M. Arnott, Esq., F.R.S., 2, New Burlington Street (Honorary).
T. H. Huxley, Esq., F.R.S., 14, Waverley Place, St. John's Wood (Honorary).
H. W. Porteus, Esq., M.D., Madras (Honorary).
Professor Goodsir, Edinburgh (Honorary).
J. H. Green, Esq., F.R.S., Hadley, Barnet (Honorary).
W. Laurence, Esq., F.R.S, 18, Whitehall Place (Honorary).
W. Sharpey, Esq., M.D., F.R.S., 33, Woburn Place (Honorary).
Sir Charles Trevelyan, K.C.B., 5, Grosvenor Cres. (Honorary).
Mr. J. H. King, Cambridge House, Portsmouth (non-resident).
Mr. H. J. Virgin, 63, High Street, Oxford (non-resident).
Mr. J. Wheeler, High Street, Portsmouth (non-resident).
Mr. W. Broadway, 23, Gilbert Street.

The following Donations were made to the Society:—

By Edwin Saunders, Esq.—A complete Series of the American "Journal of Dental Science."

By G. Bartlett, Esq.—Bell "On Injuries of the Head;" two numbers of the American "Journal of Dental Science."

By J. Saunders, Esq.—Hunter "On the Teeth;" Fox's "Natural History of the Teeth;" Arthur "On Adhesive Foil;" Blake's "Essay on the Teeth;" Bell "On the Teeth."

By J. B. Fletcher, Esq.—Bew "On Tic Douloureux;" Bew "On the Teeth;" De Loude's, Shurlock's, Rausseux's, Deserabode's, Lintot's, and De la Fon's Works.

By W. K. Bridgman, Esq.—Some preparations illustrative of his paper on Absorption.

GENERAL MONTHLY MEETING.

Monday, May 5, 1862.

JOHN TOMES, Esq., F.R.S., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Mr. Smollet W. Clarke, Madras (non-resident).
Mr. Alfred Jepson, Leamington (non-resident).

The following Donations were made to the Society:—

By Mr. Montague Alex, of Cheltenham.—A large mass of salivary calculus deposited upon a lower canine tooth; only the apex of the crown was visible, the rest of the tooth being entirely imbedded in the concretion.

By Mr. Martin Magor, of Penzance.—A model showing abnormal position of the two bicuspids and third molar of the left side of the upper jaw; the second bicuspid lying in a horizontal position, with the labial surface imbedded in the gum, the masticating surface being directed towards the mesial surface of the first molar; the third molar inclining obliquely forwards. Also models showing the effects of attrition on all the teeth of both upper and lower jaws, each maxilla containing the full complement of teeth.

By Mr. Charles James Fox.—A series of illustrations of different forms of files.

Mr. E. Truman read a paper—

On the Manufacture of Mineral Teeth.

Mr. President and Gentlemen,—I am about to give you a rambling history of my search, mental and physical, for the principles on which depend the strength and beauty of mineral teeth. I choose

this arrangement, first, because it will render my subject more interesting to our younger members; and secondly, that I may, as I proceed, acknowledge the sources from whence my knowledge is derived.

The universal use of porcelain as a material of which to construct artificial teeth renders a knowledge of its manufacture, chemical combination, and properties under various influences essential to the Dentist. All materials used in the arts have to be viewed in three aspects — 1st, their source, constituents, and combinations; 2nd, the treatment they will be subjected to in the processes of manufacture; and 3rd, the properties required in the product.

In the manufacture of porcelain all three of these views present great diversity, and require separate and especial study.

1st. The constituents of this substance are numerous, and vary much in quality.

2nd. The treatment of this substance is even of more consequence than its composition, as from the same constituents, combined in the same quantities and with equal care, a difference of treatment will produce two entirely different results.

3rd. Porcelain is required to possess varying properties suitable to the very various purposes to which it is applied. For Dental purposes alone many kinds of porcelain are required; and as, then,

no one form of porcelain is endowed with all the properties we want, many kinds of that substance are required for our purpose: therefore, it is essential that this substance should be thoroughly investigated.

In most manufactories the secrets of the art are jealously guarded by the manufacturer, but in none with the same rigidity and persistence as in those of earthenware, — a circumstance that renders the introduction of porcelain for new purposes doubly difficult, it being almost impossible for the student to master the rudiments. Until lately, in the few books written on the subject, scarcely anything beyond the history of the art and its early processes is given. So secretly indeed has this branch of art been followed, that even Wedgwood has not left behind him a line to guide us to reproduce his bodies and effects. During the last few years a few good and useful books have appeared, but even now every novice is left to discover anew for himself much that is well known and hidden by those around him, and this arises in a great measure from practice being far in advance of theory; for experienced workmen produce many effects which chemistry cannot account for. With these facts before me, in 1851 I commenced my search after what I may call the philosopher's stone, or rather, as poor Palissy would have said, the white enamel; but in my case a body that should possess the requisite properties

for artificial teeth—viz., strength and the power to resist alteration of temperature, with that creamy-like appearance which natural teeth so eminently possess, and which was not then to be found in porcelain generally. I sought first, among the mineral teeth already in use, the absolute state of things then existent. I examined the teeth of the various manufacturers: some were very transparent and deficient in strength; others were stronger, but too opaque, and moreover defective in shape. In fact, to my mind, there was not one tooth combining all the requisites, and none were of natural appearance; they would pass in the mouth for teeth, but as products of art they were by strict criticism defective.

In looking to books for help, I found a few American works on the subject, and one or two small papers emanating from English Dentists; but the latter merely gave simple formulas, some of which were incomprehensible from the omission of necessary information, while many were impracticable. Here are two formulæ from the same page of an English work: —

1st ... Feldspar 18	Disintegrated, 6	Kaolin, 2	Silex, 12
2nd „ 36		„ 3	„ 2

If one is right, the other must be wrong. Which is best?

In some of these works materials were mentioned of which we have no samples in England except in museums, and concerning which no

guidance was given to enable us to discriminate in their selection. To apply to manufacturers was useless. What, then, was to be done, but to commence the study of porcelain, and, by dint of perseverance and labour, work it out experimentally? In describing the measure of my success, it will not be necessary to weary the meeting with all the dry details and analyses through which I waded, or mention all the thousand failures that saddened me. I have bright sunny days of hope, and kindnesses received from many, to recount, that fill me with joy as I look back on the last ten years spent in this research, which show how the lovers of high art will help forward the industry of the poor student, and not lock up every particle of knowledge that will produce a shilling.

After becoming conversant with the general outline of porcelain manufacture from books, especially from Knapp's "Chemical Technology," I found one of my workmen, Mr. Grinton, had done something in the making of mineral teeth in Edinburgh, and from him I received this formula:

Feldspar	1 oz.	Crystal	10 grs.
Pumice	2 sc.	Rutile	1½ grs.

We at once put the formula into operation as well as we could. Our moulds were plaster, taken from other teeth; and for baking I built a furnace on what was thought to be a good principle. It was an ordinary enamel furnace with a muffle, having

a flat bottom, straight sides, and a round top. We used coke as a fuel, and placed test-pieces of the body, which were withdrawn at intervals through a door for examination. A product of this our first essay is on the table, marked No. 1, and with the results of the experiment I was, on the whole, well pleased, and determined at once to produce good moulds and some teeth for use, as it was evident, even at this early stage, that great practice would be required to make a good tooth. Moreover, a pyrometer to measure accurately the heat became an imperative necessity. I next arranged to visit the Potteries, and get a more practical knowledge than books could give. With this view, the Staffordshire works, where admittance could be obtained, were visited, and much information in ordinary porcelain working was gained, especially from an old schoolfellow, Mr. Thompson, of Woodville; but in none of the works inspected have teeth been made: their bodies entirely differed from that required, and most of their operations were not at all applicable to our use. I next applied to one of the large houses to supply me with materials, and having told them my object, asked them to help me. The materials were supplied, I believe, to the best of their ability; but no information was given, and the employés could not conscientiously impart to me the particulars of bodies or of causes. One gentleman gave me a bit of body,

but would not tell me of what it was made, nor the method of treatment. That product is marked No. 2. I believe it to be a good body. I had some time before attended a course of lectures at the Museum of Practical Geology, by Dr. Percy, and I requested him to find me a practical chemical assistant, capable of aiding me in these investigations. Dr. Percy introduced me to Mr. Dick, a gentleman of great ability and industry; and here let me say that the hours spent by me in his society over our furnace were very pleasantly passed. Mr. Dick suggested a series of experiments, to ascertain—first, in what the strength of mineral teeth themselves consisted; and second, if other minerals than those already tested would produce a better body for teeth, as cost would not be an impediment. The results of our first proposition I shall give hereafter. Our second I will dispose of at once. We commenced by taking feldspar alone as our fixed minimum, and that of a kind which we could procure of uniform quality in any quantity. And I may say that all my experience has tended to show the wisdom of this suggestion, both as regards the material itself, and also its uniformity; for it is a substance so often mixed with other minerals, and especially with quartz, that before using it the particular specimen should be well tested, otherwise, as has often happened to me, all the future labour will be thrown away. I shall

presently show what I recommend on this subject.

Apatite was the first mineral that we tried; and our plan was to take 100 grains of material for each test, altering the proportions by a gradual increase of the material added to the spar, and baking ten tests of each mixture, as thus:—

Feldspar, 98	Apatite, 2	Feldspar, 85	Apatite, 15
„ 96	„ 4	„ 80	„ 20
„ 94	„ 6	„ 70	„ 30
„ 92	„ 8	„ 60	„ 40
„ 90	„ 10	„ 50	„ 50

The mixtures were ground up together in distilled water, excess of which was drained off on a porous tile; some teeth were made out of each mixture. Next feldspar, apatite, and fluor-spar; then feldspar, apatite, and quartz; afterwards beryl, pumice, magnesia, petalite, various clays, pure alumina and silica, and many other substances, in every proportion, together and separately, and with all the varieties of feldspar we could procure,—a strict account of the particulars first named, and of the results of all our bakings, being kept. The results were not very satisfactory, though the labour was great, and at the time so little pleased were we, that Mr. Dick, who was called away to an important appointment in Spain, said he believed we left off just where we began. That, however, was not the case, as I had gained the experience and advantage of his

excellent method of investigation for my future guide. My workman also, with whom I first worked, left me at this time to go to America, and therefore, being again alone in my labour, I endeavoured to perfect my moulds, which I constructed of gutta-percha, taking natural teeth as fine and large as I could get them, that their extra size might allow for the shrinking of the material, and in some instances cutting them into halves, and inserting a slice of wood or ivory between the several portions, to increase the width; sometimes, also, cutting the teeth across, and inserting a plate in the interspace to increase the length of the enamel. Then I embedded the natural tooth not quite half way in a perfectly smooth, flat surface of gutta-percha, putting four or six into one mould, the gutta-percha being moulded in an iron frame, with a moveable bottom and top that exactly filled the inside of the ring or box, but would move up and down within it. I afterwards replaced the gutta-percha base, together with its embedded teeth, and on them put a given quantity of soft gutta-percha, and on that the moveable top, and submitted the whole to pressure in a very powerful press. The result was, of course, an elastic mould, with a three-quarter impression of the pattern tooth. Thus were gained some very essential points not hitherto attained (a most perfect mould of the enamel surface, every

characteristic being accurately preserved, and also a perfect profile)—(a matter of the greatest consequence, as these teeth, when cut on the crown, always present a natural appearance), the elastic nature of the mould permitting the exit of the moulded tooth through an opening otherwise too small. On slightly bending the mould backwards, the teeth fall out on to a sheet of wadding, quite perfect. These moulds I have always since used, and if made of good gutta-percha, properly prepared, and kept in water when out of use, are very durable, and after they are worn out, a very few minutes will reproduce them, as the same material will do again, and the matrix in which they were made remains uninjured. A great advantage in this plan is, that the pattern teeth, if large, need not be injured at all, so that we can copy any fine teeth from specimens we may have or borrow without detriment to the preparation from which they are taken. The moulds I have described apply to half-teeth only. If a back is used for putting in the pins, it may be either metal or plaster. If the teeth are cast—a process which I hope to explain at a future time,—of course plaster backs are the thing. If pressed metal, for tube teeth, the matrix must be different, or the moulds altered after they are made; for molars and bicuspids, or for vulcanite teeth, the moulds are made in several pieces, as shown on the table, and this,

with gutta-percha, is very easy, as this substance will not adhere either to itself or to metal, if one of the surfaces is cold, and it can be planed like wood, so that a perfectly smooth, even, rectangular surface is readily procured. The moulds are a very important matter—in fact, after a good body, the most important in this manufacture—and if made in metal the cost is very great, consuming the largest amount of the capital employed, as they must necessarily be very numerous to produce the great variety of sizes and shapes required. They also take so long to make, that any change in shape, or even alteration in size of the teeth, is a serious affair; whereas by the proposed plan every variety of tooth can be imitated, even for particular cases, with the greatest facility and at little cost. Not that cheapness is so very desirable—our primary object is to attain perfection; and if a better method can be shown—one, that is, that would produce a nearer resemblance than this can to natural teeth—that method should be used, regardless of cost. It will be found that the cheapest road in the path of original investigation is so much the longest that few can afford to travel by it.

The moulds being an accomplished fact, and the beauty of form being attained, a great many teeth were now made, using different bodies, always endeavouring to have two or three series of experiments simultaneously in progress, and never

forgetting the principles sought for—viz., strength, beauty, and endurance of vicissitudes of temperature in the product. The nearest known porcelain to this standard was the Berlin, as used for chemical purposes. Notwithstanding all that has been said about trade secrets and the rigidity with which they are guarded in all the porcelain factories, I determined to go to Berlin and ask the manufacturers for help, and, as the event proved, not without an issue. To the deep interest felt by the late Prince Consort in the arts and manufactures of this country is due the success of my mission. The present King of Prussia, at the instance of the Prince, furnished me with an autograph letter to the Director of the Royal Porcelain Works at Berlin, requesting that my questions might be answered—but I anticipate. Having determined to take this long journey after my pet object, it appeared desirable, if possible, to take other Continental factories on my way, and for this and other reasons fortify myself, as far as possible, before starting, with letters of introduction from my friends in England.

I may here be allowed to mention that I owe the opportunity of obtaining the information made use of in the present paper principally to the kindness of Sir J. Clarke, who interested himself in the scientific question so far as to obtain for me the necessary introductions, and not the least valuable of those was that to Professor Hoffman,

who kindly gave me letters to Dr. Lowè of Vienna, &c., &c. With these credentials I started, passing through Holland on my way, for the purpose of visiting Delft, the birthplace of pottery in Europe. I relate all these (perhaps irrelevant) particulars of the obligations under which I have been placed, as an acknowledgment of the debt of gratitude I have contracted, and which will be contracted by those who may find available information in the paper.

The smallest particle of knowledge on the subject of porcelain manufacture is looked on as a treasure of great value, and justly, as a lifetime of labour may be saved by a momentary communication. Hence, how shall we sufficiently thank those unselfish ones who impart it to us!

The pottery at Delft is a very small affair, quite behind the rest of Europe in its wares, which are as old-fashioned as the venerable town itself; and even truly venerable in their prejudices are they who make them, for not a toe could I put within their door, although armed with an introduction from a friend of the proprietor; and, more strange still, to unlock the door with a golden key was equally impracticable. Access being impossible, I had the more time to spend at the shrine of our prophet, the tomb of Leuwenhock. I next visited Paris, and procured an order to visit Sèvres. Here, as the porcelain body is very dissimilar to ours, my motives were principally curiosity, and

the hope of gaining some knowledge of manipulation. After passing, with others, through the usually shown parts, on arriving at the end of the exhibition, the attendants informed me that my order desired them to show me all the other parts of the factory. To whose kindness I owe this advantage I know not. Thence to Berlin, scarcely knowing what to think or hope. Did the secret I sought lie in one word, or in one fact, or in a multitude of facts which I should not be able to comprehend even when told? The last was nearest the truth; but I gathered and brought home with me the materials for thought and study, and it is the purpose of this paper to place before the Society the results. Now through Saxony to Dresden to visit Meissen, the scene of Böttischer's captivity, and the birthplace of all the early European china. The journey did not end in disappointment. I knew that modern Dresden was not equal to old, either in the body or ornamentation, and I did not think to learn much. Yet I was unwilling to lose a chance, and, as the event proved, my visit was not in vain, for they exhibited some very curious modes of manipulations. My questions, however, were not answered; hence I was obliged to trust to my eyes. Passing through Prague, I learned somewhat of glass-making. Thence to Vienna, where the value of Professor Hoffman's introduction was evinced in the kindness of Professor Lowè, the Director of the Impe-

rial Porcelain Factory. On learning my errand, he at once declared his willingness to tell me all he could, and I believe no one knows more. He devoted hours of his valuable time on several days, showing me everything in the works, giving me specimens—many of which are before the meeting this evening,—directing my attention to books and to minerals we had not tried, and writing for me the addresses of persons or friends of his from whom might be procured specimens. I cannot leave this part of my journey without mentioning the name of Dr. Heider, a member of our own profession, who has devoted much time to original research. Amongst his collections were many specimens of great interest, and from him I received many valuable suggestions. Amongst others to whom Dr. Lowè gave me letters, was Dr. Krantz, of Bonn, the well-known mineralogist. I need not tell you that to visit Dr. Krantz necessitated a very long extra journey. I therefore felt that time and money should be economized. My time was all but expended; I had now been from home two months, and therefore, anxious to save time, visited Dr. Krantz at the unusual hour of six o'clock in the morning. To him I am indebted for many facts hitherto unknown to me, and for many specimens of feldspar.

From Bonn I revisited Paris, to procure specimens of Limoges kaolin. Some little difficulty was encountered, but the Director of the factory

of Sèvres told me he would send me specimens to England. I need not say he has done so: they are on the table.

On arriving again at home, no time was lost in arranging the store of information collected in my travels. It was obviously necessary to rebuild my furnace, which in its present condition did not furnish heat enough to prepare the materials as used at the factories I so recently visited. But as I hope each department in porcelain work will form the subject of a separate paper, before discussing the construction of furnaces I may proceed to give a general outline of the plans adopted to solve the second proposition of my friend Dick, the solution of which I believe I have been so fortunate as to accomplish.

The usual materials employed by dentists in the manufacture of mineral teeth are—feldspar, kaolin or China clay, and silex in the form of quartz. These are the materials of true porcelain, with, in some instances, the addition of a little lime. True porcelain, however, is not yet made in England, because we have not native materials wherewith to form the saggers or muffles for baking it. Our fire-clays are not sufficiently infusible, and therefore the English porcelain is composed of a mixture of kaolin, a plastic clay, generally blue clay, pegmatite or Cornish stone, burnt bones, phosphate of lime, chalk flints, and steatite or soap-stone. The amount of heat requisite for its

production is much less than that required for true porcelain, and the body, when finished, is not so hard and fine as that of the true product. In teeth-making the same differences exist. The melting point or amount of heat required in baking differs in all the teeth we have now in use. Theoretically, those baked at the highest temperature should be the strongest; and, if all points of the various manufacturing processes were conducted with equal care, doubtless teeth requiring the highest heat would be the least affected by alteration of the same amount of temperature, although the great heat in their preparation is by no means a security if the ingredients are not of equal expansibility, or if the teeth are not well annealed, for then no amount of high temperature employed in their manufacture will prevent them from cracking under the process of soldering; while, on the contrary, teeth that almost melt under the blowpipe, if they are composed of materials well assorted, are well made, rightly fired, and properly annealed, before they come to the Dentist, and are by him used, not abused, will stand very great and very sudden changes of temperature with impunity. Therefore, strength does not depend on height of temperature used in making; my experience goes to show me that it greatly depends on the points last named—viz., the materials used should expand and contract equally; while the body should be well prepared,

and the firing be with special care carried only to the point of giving a beautiful vitrified surface to the work, and not a degree beyond, or all the strength will be lost. The right amount of heat depends on the bodies, no two bodies requiring the same temperature; and this is only to be learned by experiment. The temperature must, from its highest point, be let down as evenly and slowly as possible. These points attended to, a strong tooth is the result; and I think, therefore, that teeth made without enamel—those fired at one heat—are likely to be the most durable. In the old French teeth, which you know it was almost impossible to crack in soldering, the strength arose from the body of the tooth being of strong opaque porcelain, not fired up to the point of vitrification, and covered with a glaze well suited to the body, but without regard to any natural effect.

I do not suppose many of you will make mineral teeth, but you may wish to make block-work or continuous gum, and the rules applicable to the making of teeth and the preparation of the materials are the same for all mineral work; and the principles once mastered, it is astonishing with what facility mineral teeth are used. I believe, in my workroom, my men would prefer to put a tooth through the fire to any other mode of fastening, for breakage so seldom occurs; and the only means we use are those I believe con-

stantly employed. But we have hitherto (until the founding of this Society) known so little of each other, that it is difficult to say what is generally done; I must, therefore, limit myself to relating the plans used by myself. The piece is inclosed in plaster and sand, and put into an iron tray, which is placed on the furnace till quite hot, the temperature rising gradually. The piece is then placed in the fire on the tray till it is all quite red hot, after which it is soldered with the blowpipe in the usual manner, and allowed to cool gradually. In this way very large pieces of blockwork may be soldered.

The durability of mineral teeth also greatly depends on their size and mode of fixing. I have tried many arrangements for attaching the mineral tooth to the plate. I inserted platina gauze in various forms into the back of the tooth. The strongest, but by far the most difficult to use, is a square gold pin, bent to follow the shape of the tooth, and soldered with gold to platina pins in the interior of the tube. This mode of fastening, which I think you will say is a most beautiful specimen of Dentistry, is the invention of a young lady. In very small teeth, the gold back must be made to take all the pressure, as they generally give way in mastication; very large teeth, on the contrary, are more liable to break in soldering. The position of the pins in half-teeth is a matter of great consequence. The strongest

form for general use is two good pins properly headed, placed one above the other in the length of the tooth, and it is of the first importance that the pins be well embedded in the mineral, which, of course, should be as tough as possible; and I would say that, in all cases, the base of the mineral should rest firmly on the gold plate in front, almost to the edge of the tooth, so that pressure from behind cannot bend the tooth outwards. Again, it is not possible for any mineral teeth to stand in the front of the mouth if the pressure in mastication is allowed to fall upon the back of them instead of upon the proper place. The molars, from their size, will bear it with impunity if the teeth are good; and as they are usually tube teeth, the pin has not a cone of solder at its juncture with the plate to act as a wedge in the whole of the tooth, which is a common source of destruction. Vulcanite teeth stand best, because they are not required to undergo great vicissitudes of temperature suddenly, and because they have necessarily a firm, good bed to rest on; but they are readily bitten out if the back do not protect the front teeth as they should do. I confess I totally ignored most of these points, thinking the mineral in fault, till by experiment I found it quite the reverse.

I have said the materials for making mineral teeth must be properly prepared, and I will endeavour to show how. First, of feldspar,

which should be chosen quite free from quartz and other impurities, of as transparent and uniform a quality as possible, and certainly from a source whence any required quantity can be procured, or otherwise you will never get two batches of body alike (see analysis of various spars). Make it red hot, and plunge it into pure water. I may say at once the water used in all porcelain work should be distilled, for otherwise it may be a constant source of error. Now coarsely grind your spar in a Wedgwood mortar; and again it is most essential that the mortar should be veritable Wedgwood, or your body may become opaque or discoloured by mixture with the particles worn from your mortar by friction. Place the ground feldspar in a crucible, the most refractory you can get, and melt it. This will require a very high temperature if the quantity is great, but it is a point of such importance that it cannot be omitted without great detriment to your ultimate product. I built a furnace on purpose to melt my spar: it is circular, eighteen inches deep, by fifteen inches in diameter, with three inlets for air, and two exits, with a shaft of seventy-five feet, unbroken draft, eighteen inches in diameter; and with this furnace the materials can be very readily melted: in small quantities it can be done in any ordinary clay furnace. The melted spar will be very much more transparent than it was before, and more compact; besides, it will enter more

readily into combination with your other materials in your next firing.

Break up your mass after it is cold; carefully grind off all the portions of pot that stick to the spar; again make it red hot, and plunge it in water preparatory to again grinding it fine enough for washing, — a process by which all porcelain materials are obtained of an equal degree of fineness. This process being well known, I need not describe it. It has been said that the spar should be much coarser than the other ingredients, as it gives greater transparency. This may probably be the case, as that quality seems to depend on the transparent flux saturating the opaque body, as oil does paper. Under the microscope the two ingredients, kaolin and feldspar, can be clearly distinguished separate from each other, and the milky mass seems a transparent ground, mixed with an opaque ingredient. Ehrenberg observes that it consists of articulated threads or little rods, which are interwoven, and cross each other in all directions. (According to the microscopic observations of Oschatz and Wächter, the porcelain mass consists of a vitreous matrix which is intersected in all directions by innumerable crystalline needles of the most minute dimensions, and its want of transparency is due to the reflection and refraction of the light from the surfaces of these crystals.) This point I shall leave to the fancy of the user till more is

known definitely. I use my spar rather coarser, because I like to follow the recommendations of those who have had experience, and I have not yet had time to investigate the subject for myself.

The clay and kaolin should also be washed, as it is very essential that these ingredients should be as fine as they can be obtained. Of clays, the blue clay is, in my opinion, the best for our purpose, because it imparts that peculiar ivory-like appearance of the natural teeth which we so much require and find so difficult to imitate. Clay and kaolin give strength, but they diminish transparency; therefore, unless fluxed, can only be used in small quantities. The crystal should be the most transparent. The optician's refuse is the best: it consists generally of portions cut from fine clear stones, but should be scrupulously washed immediately it is received, as it generally comes coated with emery— a mineral not desirable to us, though very useful to the optician. The rock crystal being heated to redness and plunged in water, is then easily reduced to a powder, though it is much harder than feldspar, and will require more time to grind. It should be the first material weighed for use, that it may be subjected to all the after-grinding necessary for mixing the body. First, that it may be itself more comminuted, and also as it assists in the grinding and mixing the other matters, especially the metallic oxides used

for colouring. Quartz, or ground porcelain, is to teeth what cement is to saggers: it prevents shrinkage, and permits alterations of temperature without cracking. It is therefore a very essential ingredient. It also gives us more transparency and hardness, but it raises the point of heat required in baking; and as it is not plastic, it must have clay with it to enable us to mould. In casting, this is overcome; but still, till biscuited, the teeth without clay are very fragile, unless gum tragacanth, soap, or glue, or other matters be added. Lime, if used, may either be in the form of chalk, bone-ash, or gypsum: the quantity required must be accurately tested; and I think the only other caution necessary is, to be sure it is pure of its kind. It has been said that bodies containing lime bear change of temperature better than those without it; but this I think very doubtful.

Any other material, I need not say, must be reduced to fine powder by the means already described. All the utensils should be earthenware, wood, or bone, and perfectly clean. It is curious to see how small an amount of extraneous matter, especially metallic oxide, will spoil the beauty of the work. I will now describe the compounding the body, which I find a good one — that is, if the materials used are like those shown to-night; but from what I have said, it will be evident that the quantities must vary to suit every fresh supply of mineral, unless the new are chemi-

cally exactly like the old, which is seldom the case: —

	oz.	dwt.
Take of—Feldspar	3	4
Crystal	1	4
Blue Clay	0	6
Rutile Frit	0	6

Mix for body.

	oz.	dwt.	gr.
Take of—Feldspar	1	10	0
Crystal	0	6	0
Blue Clay	0	1	0
Cobalt Frit	0	0	6

Mix for point.

The Colouring Frit—

Rutile	1 dwt.	Cobalt	2 gr.
Spar	1 oz.	Spar	1 oz.

These teeth are very light tinted.

The materials having been thus prepared, weigh dry, and make into a paste, if for moulding (the process usually employed), with distilled water in a large mortar, and well mix; even the order of doing this is essential — the crystal and colouring matter first, and ground for some time alone, then add the clay, and again grind them well together; now the spar, portion by portion. In pouring — a process which gives very much extra strength, but which would occupy a whole evening for me to describe,— the materials are made into a fluid slip, and poured liquid into the moulds, and should be all fritted together and reground. Time improves all bodies. After they are mixed, if they are kept damp, the more the dough is kneaded to expel the air and solidify it, the better; there

should be no air between the particles if it could be prevented; and that tooth which is the most compact before baking will (all other points being equal) be the strongest after.

I do not follow the usual plan of making the teeth, biscuiting them and enamelling afterwards. Having prepared my two kinds of mass, the one for points, the other for the body, I fill both into the mould, the points first, the body after; by this means they blend perfectly. And as the point mass is made a little more fusible, the effect is a transparent tip or enamelled surface, and the markings on the enamel of the natural tooth are produced on the point as in the body; this method, with accurate firing, produces, as you see in the teeth I now show, a very perfect resemblance to the natural enamel. They were moulded in the gutta-percha moulds I handed to the President, and fired by my pyrometer, at a temperature which rendered them quite invisible through the test-door of my small furnace; the heat was raised very evenly and slowly, and the teeth left untouched till the furnace was quite cold, from Saturday night to Monday morning. I would say of colouring materials, I think they should always be fritted—that is, a given quantity of oxide mixed with spar should be ground together very finely and vitrified; on this mass being again ground fine it can be more accurately weighed, and also the colouring power of the metal be

more certainly known. In rutile, for instance, no two crystals will give exactly the same tint, but if fritted, the whole is uniform; and after vitrification, the tint of colour can be well judged of. Thus the beauty and the strength are both attained.

I shall go no further to-night. To give the whole knowledge of mineral work would be quite impossible in one paper. I fear I have wearied you already; but if the subject has sufficient interest in your eyes, I shall be happy, next session, to continue my report, and to include all the varieties of blockwork and continuous gum, in which department I show you a few specimens, but in which the principles herein laid down for the making of teeth are more fully carried out, the larger and more complicated structure requiring a higher development of our art. I know much has been done in blockwork by Mr. Barkley, Mr. Heath, and others, and lately by Mr. Patrick, who is the first, I believe, who will teach its manipulation. I know his processes, and think them very good. The teeth now in use in England are much improved in shape, and also in strength, since I began; and for the latter quality, with proper treatment, do their duty very well. I cannot say so much for their natural appearance, although that is much improved; but I hope the use of the mould I have described will become general, as there will then be no

reason why the highest point of peculiarity in natural teeth should not be imitated. Every maker has his own body, any of which will make good teeth, if care be used in treatment and firing.

Gentlemen, it has been said in this room, and very truly, that some of the great physiological problems have been, and may be, solved by Dentists. The problem I have endeavoured to demonstrate has been often solved, but we have been left again in darkness as to the solution.

We read that the potters of Yesd, in Caramania, sent one day to the potters of Ispahan a vessel of porcelain which would hold six English quarts of water, and weighed only half an ounce, and this of porcelain that could be used for mortars and bullet-moulds. Wedgwood produced porcelain that would emit sparks when struck with steel, capable of receiving a high polish, of resisting acids, and of sustaining a high temperature. Where are the formulæ, the treatment of materials? The materials themselves, what were they? We may, perhaps, buy the vessels, but the facts of making are as much hidden now from the world as they were in the days of Böttischer. I trust a better light shines with us—the light of true science, whose rays not only illuminate the path of the present, but penetrate the darkness of the future, and last for all time.

The specimens of materials used in the manufacture of porcelain which I have collected during

my search, and which I have brought to show you, I intend for your museum. In begging your acceptance of them, permit me to express a hope that they may be followed by the presentation of any mineral substances used in this manufacture that the members of this Society, spread over the surface of our globe, can procure; and I trust that the greatest care will always be used both to procure the specimens as fine and pure of their kind as possible, and to preserve them so for future use. In books, a little dirt only spoils the appearance, and if they are misplaced they can be reassorted, but in these things the least dirt or mixing spoils the whole.

GENERAL MONTHLY MEETING.

Monday, June 2, 1862.

JOHN TOMES, Esq., F.R.S., President, in the Chair.

The following Donations were made to the Society:—

By Mr. Alfred Hill.—Ruspini's "Treatise on the Teeth," and a preparation exhibiting fungoid growth of the dental periosteum.

By Mr. Edwin Saunders.—A box of Japanese tooth-powder from Jeddo.

By T. G. Palmer.—A model, exhibiting five incisors in the upper jaw, with mal-position.

By Mr. W. A. Harrison.—A life-size bust of John Hunter.

By Mr. John Martin.—A life-size bust of Professor Owen.

By Dr. Roberts, Edinburgh.—A specimen of bone-work fifty years old; the entire lower set of teeth, bound together with gold wire, taken from the mouth of the late ex-Queen of Oude; also two smaller specimens exhibiting a similar method of treatment.

The President announced that the Society had received a donation of money, to be expended on a gold medal to be awarded to the writer of the best essay on some subject in Dental Surgery, to be determined by the Society. The question had been referred to a committee, which had presented its report, and the Council were in a position to place before the members, and those who might be prepared to enter upon the contest, the conditions on which the gold medal would be

awarded. The subject chosen was the "Pathology of Dental Caries;" and he hoped he was correct in expressing the opinion that many essays would be sent in, and that the medal, which would be presented to the successful candidate, would be fairly and stoutly competed for. He likewise stated that copies of a paper, giving the conditions on which the medal would be awarded, were upon the table for the use of the members.

The following is a copy of the paper alluded to:—

ODONTOLOGICAL SOCIETY OF LONDON.

PRIZE GOLD MEDAL.

The Subject of this Prize is—

"THE PATHOLOGY OF DENTAL CARIES."

The Medal is to be written for under the following conditions:—

Candidates to be members of the Odontological Society, not on the Committee for adjudicating upon the Dissertations, or members of the Dental profession eligible for the membership of the Society.

The Dissertations to be in English, and the number and importance of original facts will be considered principal points of excellence. Recited cases to be placed in an Appendix.

Each Dissertation to be distinguished by a motto or device; and accompanied by a sealed

paper containing the name and address of the author, and having on the outside a motto or device corresponding with that of the Dissertation.

The Manuscript Prize Dissertation, and every accompanying drawing and preparation, will become the property of the Society.

Those Dissertations which shall not be approved, with their accompanying drawings and preparations, will, upon authenticated application within the period of one year, be returned, together with the papers, unopened, containing the names and residences of the respective authors.

The unapproved Dissertations which shall remain one year unclaimed, with their accompanying drawings and preparations, will become the property of the Society; at which period the papers containing the names of the authors will be burnt, unopened, in the presence of the Committee.

No Dissertation will be received if in the handwriting of the author.

The Dissertations to be addressed to the Secretary of the Odontological Society, and delivered at 32, Soho Square, on or before the first Monday in April, 1863.

Mr. E. B. Bartlett read a paper—

On the Treatment of Dental Caries.

Mr. President and Gentlemen,—After the many excellent papers that have been read to this Society on the treatment of caries and exposed pulp, &c.,

I feel diffident in bringing before you my own views and practice, especially as I have little to add to what has already been given; but I consider each member ought to give the result of his own experience for the general good, especially if he can in any way lessen the labour of his brother practitioners, or relieve the sufferings of his fellow-creatures.

We all know that the teeth, unlike other osseous structures, have not the power of reproduction, but the pulp has the power of reparation and protection. Thus we find that when the decay has extended far enough into the tooth to produce irritation, the dental follicles are filled up by bony deposit, and Nature thereby protects the sensitive part of the tooth. Sometimes we see the crowns of the teeth in each jaw worn down even with the gums (from the peculiarity of the individual's bite), the stumps remaining healthy and useful, the cavitas pulpæ having become hermetically sealed with secondary dentine. Generally during this process no inconvenience or tenderness of the teeth or stumps has been felt. Why? Because the cementum has been deposited in the same ratio as the wear and tear. But sometimes they become very tender and sensitive, from their being worn down more rapidly than the process of protection takes place,—or from the injurious effects of heat, cold, acids, or other irritants; and unless this irritation can be stopped by timely and proper

treatment, it is sure to end in alveolar abscess. Now, in order to make this law as subservient to our will as possible (as I consider there is but a step between calcification and suppuration), we must reduce the inflammation when in excess, so as to prevent suppuration, and to stimulate the pulp to protect itself by calcification; but it is necessary that all oral fluids and foreign matter should be excluded. I find nothing answers so well for this purpose as white blotting-paper, rolled into various sizes, like a bandage, and steeped in Bell's No. 3 solution of gum mastic. The advantage over cotton wool is, that the fibres being shorter, it is more manageable, there is not so much elasticity, and it remains in better. You can cut off a piece, according to the size of the cavity, and avoid, what I consider so prejudicial to success, putting too much temporary stopping, thereby either giving the tooth too much work from the antagonist pressing on the stopping, or irritating the gum by the excess touching it, and producing inflammation in the periosteum.

I will now make a few remarks on what Fox calls "the denuding process," or Mr. Tomes, in his admirable work, "erosion." We generally find this condition in people who have deep lips, and therefore I cannot but think there is a greater morbid or chemical change from the secretion of the mucous membrane than Mr. Tomes imagines (as we so often see the enamel rough, and hanging

over the dentine), and that this takes place more at night than in the day, as, from the quiescent state of the cheeks, the saliva does not mix with the mucus to neutralize the acid, therefore it acts on the cementum. (Query — Would not this be decay in an unclean mouth ?) I am inclined to the conclusion that the brush makes the difference. *Treatment.*— File the enamel smooth where it is rough or overhangs; always use the brush up and down with chalk and soap twice a day; after which use spirits of wine or spirits of camphor with a brush on the teeth, and at night place on the necks of the teeth bicarbonate of soda or calcined magnesia, as Mr. Rogers recommends; avoid the use of acids and sweets.

The agents which I have in use are a saturated solution of spirits of camphor and tannin. I use this solution in caries without exposure of pulp; but where the dentine is very sensitive, I find this combination more effective than with ether. It should be used either with cotton-wool changed twice a day, or on a small quantity of cotton rolled in dry tannin, and kept in with mastic-paper. The tooth is generally fit to stop at the end of a week.

For exposed pulp accompanied with pain, creosote, with as much acetate of morphia as it will dissolve. I moisten a small piece of cotton-wool with this rolled in dry tannin, and stop with mastic-paper as before. If the pulp is ulcerated

from strangulation, it will be of no service; if not, I find it gets rid of the inflammation, causes the nerve to recede, and enables you to stop without pain. My next agent I use both as a counter-irritant and as an escharotic—comp. tinct. iodine, or iodine four times the strength of the pharmacopœia,—and have found it of great service in reducing inflammation before suppuration has taken place, and in those cases which do not admit of Dr. Hullihen's operation. There is one great advantage connected with it — it produces but little pain, and is, in my opinion, much better than mustard or bread poultice, or even a leech; the leech we know sometimes increases the pain, if the nerve is not destroyed, while the iodine gives no trouble in applying it, and suits that class of patients we so often meet with who will not submit to an operation. Regarding its use as an escharotic, I have had but little experience; but in those cases where I have used it in strangulation of the pulp, it has done good service by applying it in the tooth and on the gum. The iodine discolours the dentine and destroys the mucous membrane; a little spirits of ammonia aromaticæ will remove the stain.

In performing risodontrephy, I would give my younger brethren a few hints. Use a short broach, and as straight as possible; it is not so likely to break, and will enter the pulp cavity more readily when it has punctured it. Always

elevate the point towards the crown of the tooth, or it will pass into the floor of the cavity of the molar teeth, and do no good. Sometimes it is necessary to insure that the cavity is kept open. The better plan is, to order your patient to pass a needle if he feels any pain or fulness, and to keep the bowels active. No doubt this operation is better performed when the tooth is stopped, if there is no chance of seeing the patient's tooth after the operation, otherwise I prefer giving the tooth an opportunity of doing without it.

The first case I had of risodontrephy was about six years since.—A gentleman with lower molar distal surface carious; nerve exposed. In town for two days. Stopped the tooth with cement; it became painful next day; drilled through the stopping into the nerve; blood escaped. The tooth has remained useful ever since.

I will conclude with the relation of three or four cases illustrating various points of practice.

Inflammation of the Pulp from Fracture of the Enamel and Dentine.

A lady, aged twenty-one, complained of great tenderness and continual pain in the first lower molar of the right side. On examination, I discovered a loss of the anterior portion of the facial ridge of the enamel, with enough dentine to form a cavity. I observed that she must have

bitten on some hard substance, as its antagonist had lost a portion of its enamel. Her mamma recollected that she had cracked a plum-stone about six months previously. She felt no inconvenience at the time, but in consequence of the exposure of the dentine to the action of irritants, it had decayed, and inflamed the pulp to so great an extent as to involve the periosteum. I removed the diseased part, dressed with creosote, morphia, and tannin, performed Dr. Hullihen's operation, which relieved the pain, sent her away for a fortnight, forbidding the use of acids or sweets, &c. The tooth remained comfortable during that time. She, however, did not return until the temporary stopping had come away, and when all the symptoms had returned. I passed a broach into the cavity, touched the dentine with nitrate of silver, ordered a purgative to be taken, warm water to be held in the mouth frequently, a needle to be passed into the cavity daily, and requested to see her again in a fortnight; I then stopped it with gold, which has proved perfectly effectual.

Case 2.—*Exposure of Pulp, and Calcification.*

A young lady with a carious bicuspid in left side of the upper jaw; the cavity on the distal surface; the pulp exposed. Treated with a concentrated solution of acetate of morphia and

creosote on cotton rolled in dry tannin, which was kept on the tooth with mastic-paper for a fortnight, at which time it was stopped with cement, and remained comfortable for nine months; when she caught cold, the tooth became inflamed and painful. She would not consent to extraction. I therefore drilled an opening into the pulp through the dentine of the facial surface; pus escaped in quantity, and the tooth became easy, useful, and comfortable. At the end of six months she returned, with a portion of the tooth broken off, and the stopping gone. On examination, calcification had taken place over the entrance into the original cavity, and still remained. I restopped the tooth; and this is twelve months ago.

I quote this case to show that, although fresh inflammation had been set up, and pus formed, the original calcification remained intact.

Case 3.—*Inflammation of Periosteum; Pulp Exposed, and Painful.*

A lady, aged eighteen, with caries of left canine of superior maxilla, had pain for a few days; exposed pulp, inflammation having extended to the periosteum and surrounding tissues as far as the eye. Removed all irritating matter; applied morphia with a small piece of mastic-paper, lightly pressed, but sufficient to protect the

nerve; wiped the mucous membrane around the tooth, and rubbed the gum well with compound tincture of iodine; ordered the same to be applied externally in the evening over the inflamed surface, and again internally. At the end of ten days, all inflammation had subsided; the tooth was stopped with gold.

Case 4.

A gentleman who was going out of town in four days, with anterior lower bicuspid decayed, pulp exposed and ulcerated, acutely sensible to heat and cold; tooth slightly loose. Wiped the mucous membrane, and applied the iodine as before; touched the pulp with iodine four times the usual strength of the pharmacopœia for three successive days, and lightly stopped with creosote and mastic-paper. On the fourth day, all sensation of heat and cold had gone; tooth firm; stopped it with cement. I have heard since that it is quite well and useful.

GENERAL MONTHLY MEETING.

Monday, November 3, 1862.

JOHN TOMES, Esq., F.R.S., President, in the Chair.

The following Gentlemen were proposed for the Membership of the Society:—

Mr. Edward Augustus Phillips, Batavia, Java.
Mr. J. R. Gurner, North Terrace, Adelaide, South Australia.
Mr. Marco Versalovich, Corfu, Ionian Islands.
Mr. G. Ash, 26, Castle Street, Dover.
Mr. James Robertson, St. Margaret's Bank, Rochester.

The following Donations were made to the Society:—

By Mr. G. Owen.—Government Specifications of Dental Patents, from 1744 to 1861 inclusive; together with the "Patent Law Amendment Act of 1852," in 2 vols.

By Mr. Bullin, of Chester.—Maclise's "Surgical Anatomy."

By Mr. Rutterford.—Some copies of Mr. C. J. Fox's Appointment Tablets, bound in different forms.

By Mr. Marco Versalovich.—A Photograph of the Dental Diploma granted by the Ionian Academy.

Mr. C. De Lessert said he had great pleasure in introducing to the notice of the Society a small portable hand-lathe, which he had found very convenient. He had brought it to town with him to show to the members, in the hope it might be of some service (or rather a copy of it might be).

He knew that such a thing was very much required, particularly by provincial Dentists. He resided in the country, and had found the want of such a thing. As he had constructed it himself, it was rather rough. The frame-work was cast iron, the cog-wheels gun-metal, the large centre-wheel mahogany, and the lathe-head one of Ash's.

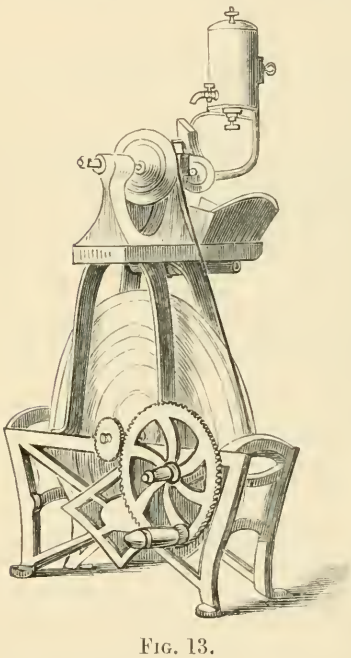


Fig. 13.

Although it can all be taken to pieces in a few minutes, yet he found it more convenient to keep it together ready for use. The water apparatus folds down on the side by means of a swivel joint. It stands $16\frac{3}{4}$ inches high, is 12 inches in length, and 4 inches wide, weighs twelve pounds, and is to be turned with the left hand or by an attendant, after the manner of a coffee-mill. It could be screwed upon a bench, or upon an old kitchen table, and the corundum wheel revolved as fast again as on one of Ash's lathes.

Mr. Vasey read the following paper—

On Retarded Development of the Permanent Teeth.

Mr. President and Gentlemen, — I was influenced in my selection of a subject for the paper I undertook to read this evening by an article in the last number of the "British Journal of Dental Science," in which the editor draws attention to the class of papers he thinks best adapted for our meetings. Practical subjects are, as he remarks, most acceptable, and are undoubtedly the most useful. All theoretical ones are, in fact, only valuable in so far as they lead to practical results.

Practical subjects may be divided into two classes — viz., those that are of every-day occurrence, and those that are only occasionally so. The latter class, although at times very embarrassing, are, however, always interesting, and, I think, admirably suited for discussion in this Society. One of these I have therefore chosen on this occasion, and the subject is Retarded Development of the Permanent Teeth. Although these cases come only occasionally under our care, still we cannot overlook their importance to the individual sufferer of such malformations, — a term I consider some cases would warrant me in using. Where the perfect beauty of a young lady is destroyed by any such imperfection, or where the resorting to artificial teeth is rendered neces-

sary, I have found these defects the source of the deepest anxiety and mental suffering. No rule of treatment could be safely adduced from the limited number of such cases likely to fall to the lot of any one member of the profession; but our individual experiences added together might in time give us not only important but reliable results, and lead to an appropriate mode of treatment.

I was consulted, some years ago, by a young lady, aged eighteen, who had all her teeth fully and perfectly developed, with the exception of the superior central incisors. Her mouth, to the casual observer, presented exactly the appearance as if the two teeth had been extracted. At first sight, it was difficult to believe that such had not been the case. On carefully examining the mouth, however, a fulness was observable on the external surface of the gum, on the right side, and very high up, that, to my mind, indicated the presence of a tooth. I made two transverse incisions, and removed the intervening piece of gum, — the portion which covered the cutting-edge of what proved to be the right central incisor. In a few weeks this tooth descended as far as is shown in Fig. 14, taken with the others from the models on the table. The gum, I may here remark, was very hard, and somewhat difficult to cut; but there was no pain or uneasiness whatever in

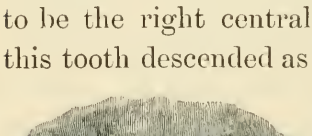


Fig. 14.

the part. At a subsequent visit, I performed a similar operation on the left side, there being sufficient evidence at that time of the presence of another tooth. The one that descended on this side, however, proved to be a supernumerary one, with a prominent cusp posteriorly, giving it somewhat the appearance of an irregular inferior bicuspid (Fig. 15). This tooth, nevertheless, looked better than the space; I therefore decided to leave it until such time as a better shaped one seemed likely to take its place, which I confidently expected would be the case, feeling somewhat convinced that the presence of this abnormal tooth had in some way or other been the cause of the non-appearance of the natural organs in their time and order.

Fig. 15.

Some few months later a fulness appeared just over the supernumerary tooth; on repeating the operation I had performed on the previous occasions, I could trace the edge of the proper incisor. I therefore extracted the supernumerary one, and the tooth that was subsequently developed was a well-formed incisor, like its fellow on the opposite side (Fig. 16).

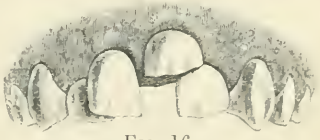


Fig. 16.

About two years after the extraction of the

supernumerary tooth, another appeared on the other side, immediately behind the incisor (Fig. 17); this, I need hardly say, I at once removed.

Fig. 17.

An irregularity in the position of the lateral incisors the patient would not consent to have remedied. The delay, anxiety, and inconvenience occasioned by the retarded eruption of the teeth caused her to place the greatest value on them, and impressed her also with a dread of having them operated on in any way, in case of some unfavourable result, the present condition being viewed as a most favourable termination to what at one time appeared likely to prove a permanent deficiency.

Let me now draw your attention to two points in the development of the teeth in connection with the eruption and calcification of these organs. Mr. Tomes, in his lectures on the anatomy and physiology of the teeth, says, "When once the tooth is cut, growth progresses rapidly. The tooth, however, appears to grow more rapidly than it really does, and from the following cause:— The sac being opened, and its inner surface thereby rendered continuous with that of the gum, a strong disposition to contract seems to come into force in that portion lying against the enamel; and as the gum constitutes one fixed

point, and the adhesions of the sac to the neck of the tooth the other, the crown is, as it were, lifted out of the gum by the shrinking of the sac between these two points. As a consequence of this movement, the distance between the unfinished end of the fang and the fundus of the alveolus is lengthened. The socket now rapidly adapts itself to the neck of the tooth, to which it becomes rapidly moulded. The pulp elongates itself, and diminishes at its base, till, at the completion of a tooth, it has diminished to the size of a thread, and is constituted principally of the Dental vessels and nerves."

With respect to the calcification, I have only to remind you that in the incisors it commences at the age of six months, and is complete, in so far as the length of the tooth is concerned, at about the tenth year.

Bearing in mind the foregoing account of the eruption of the teeth, and the time of calcification and eruption of the incisors, we cannot help trying to realize the precise condition of the teeth in such cases as the one I have just described,— a condition that would at such an age give vital force sufficient to bring the teeth through the eruptive stage. If I had had the opportunity of examining or opening the sockets of the teeth in this case, should I have found the teeth fully formed according to the age of the patient? Certainly, according to authority and teaching, such de-

velopment should have taken place. A tooth, the development of which has once commenced, we believe to continue its progress to completion. And if, from any abnormal condition, the eruption through the gum is prevented, the tooth is developed upwards in the alveolar process. There are specimens extant in which teeth are seen in almost every conceivable position, enclosed in the alveolar arch.

Mr. Tomes, in his "Dental Surgery," says, with respect to such cases, "Teeth, so placed, may remain without producing inconvenience through a long life, and be discovered only towards its close. When, with advancing age, the teeth fall out, and the alveolar processes disappear, the long-hidden teeth are brought to light, and the patient fancies he is cutting a third set of teeth."

When the teeth are completely formed in the socket, can we take it as a rule that the active force necessary to bring them through the eruptive stage has been expended? The author just quoted says on this subject, "All attempts at treatment would, in such cases as that which is figured, necessarily be useless, supposing the development of the root to be advanced." Also, "The central incisor would have probably occupied the usual place had the supernumerary tooth been removed on its first appearance through the gum; but had its extraction been performed after the completion both of itself and the displaced central

tooth, no advantage would have been gained by the operation. The position of the central incisor having been unalterably determined, the space left by the extraction of the intruder would have remained unoccupied."

If the teeth in the case before us had followed the usual course of development to completion, it is almost inexplicable how they could have gone through the eruptive stage after the eighteenth year.

If we realize the teeth in a half-formed condition, as represented in Fig. 18, the eruption is easily enough understood. But then we have the difficulty of determining how the development could be in abeyance for so many years, lying dormant for such a length of time, and then springing into activity.

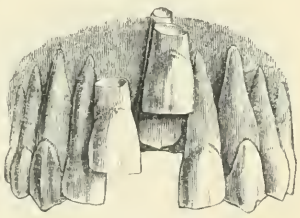


Fig. 18.

How far such cases are influenced by the presence of supernumerary teeth, is another most interesting point, and brings to my mind Mr. Tomes' remarks, "That the history of supernumerary teeth has not attracted that degree of attention at the hands of practitioners which the subject deserves. There are several points the investigation of which would be attended with advantage. Thus, we find that supernumerary teeth, for the most part, are matured, and make

their appearance before the permanent teeth situated in the same part of the mouth."

A clear conception of Nature's working under such circumstances would be of great practical service to us in cases of a less important nature, but still, as I previously mentioned, important enough to the individual sufferer; such cases, I believe, are of frequent occurrence.

Fig. 19 represents one of this class: it is from the mouth of a gentleman, aged seventeen, who had been, from an early age, under the care of a very eminent member of the profession. From the case being left to Nature's guidance until that age, I presume the expectation was, that the tooth would develop to its full length, either anteriorly or posteriorly to the other teeth, and that it could then be reduced to its normal position. In the majority of cases such would most likely be the termination. But in this one it has been otherwise. The gentleman is upwards of twenty; the tooth is wedged high up between the teeth, as shown by the model, — most unsightly to the ordinary observer, but provokingly so to the professional eye.

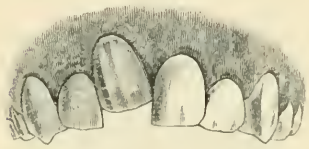


Fig. 19.

In such cases, it would be most desirable if we could form some estimate of how far teeth so placed are likely to advance, if sufficient space

were given to them, and up to what age anything like active treatment might be considered safe or advisable.

Even this subject did not escape the acute observation of the great Hunter. In his justly celebrated "Natural History of the Human Teeth," he says, "The manner of their formation likewise shows that teeth cannot grow beyond a certain limited size. To illustrate this, I may observe that I have often, in the dead bodies of adults, found the left cuspidatus of the upper jaw, with its points scarcely protruding out of the alveolar process, though the tooth was completely formed, and longer than the other by the whole point, which in that other was worn away. This tooth, at its first formation, had been deeper in the jaw than what is common; and after it had grown to the ordinary size, it grew no longer, though it had not the resistance of the opposite teeth to set bounds to its increase. Yet, commonly, in these cases, the tooth continues to project further and further through the gum; though this is not owing to its growing longer, but to the socket filling up behind it, and thereby continuing to push it out by slow degrees."

Here we have the suggestion of the addition of bone in the socket, as accounting for the eruption of the teeth. Such may have been the condition in my case, but the spontaneity of its growth at such an age, and only to the extent of bringing

the teeth to a normal length, is somewhat difficult to comprehend.

Of how far the development may have been accelerated, or whether it was in any way affected at all, by the incisions I made, I will not venture to give an opinion from the limited experience of one case only. The tooth, however, last erupted, and that the one that was remarked as coming through the gum more slowly than the others, was the only one over which no division of the gum had been made; and was, moreover, a supernumerary tooth, which, as a rule, should precede the permanent teeth in the same part of the mouth.

GENERAL MONTHLY MEETING.

Monday, December 1, 1862.

JOHN TOMES, Esq., F.R.S., President, in the Chair

The following Donations were made to the Society :—

By Mr. S. A. Kirby.—A wax preparation, exhibiting a long cyst in a lower jaw, containing a canine tooth at bottom of cyst, and a lateral incisor lying obliquely on surface of alveolus.

By Mr. P. A. Kolliker, of Zurich.—A mass of tartar, weight 100 grains, removed from a lower jaw.

By Mr. Ramsay.—A lower jaw containing several teeth filled by him with Ash's No. 8 gold foil.

By Mr. Deacle Saunder.—Models and apparatus, by means of which he had expanded the upper jaw, extended the alveolar arch, and created a space between the lateral incisor and anterior bicuspid (the distal and mesial surfaces of which were in contact with one another), sufficiently large for the transmission of the canine tooth.

By Mr. Arnold Rogers.—A wax preparation of osteo-sarcoma of the upper jaw; an injected preparation of the jaw of a fœtal calf; and the minute teeth from the mouth of an elderly female. The patient had lost all her other teeth from ptyalism, aged 55.

By Mr. J. B. Fletcher.—The principal forms of the Skeleton and Teeth by Professor R. Owen.

Mr. W. M. Bigg presented his portrait.

The President announced that the Council had purchased for the Society, from the International Exhibition, a most beautiful series of maxillæ in almost every phase of development, as well as a disarticulated skull for the Museum.

The Honorary Secretary read a paper, by Mr. Tomes,—

On a Case of Supernumerary Teeth, treated by Mr. Tellander.

Mr. President and Gentlemen,—An eminent member of our profession—Mr. Tellander, of Stockholm—has placed in my hands for description a case of unusual interest, and of such rare occurrence that so far as I know it stands alone.

In March last a female, aged twenty-seven, applied to Mr. Tellander for professional assistance. He gained from her the following particulars respecting the history of her case. The temporary teeth attracted no attention, and it may be assumed that they presented no unusual characters. They were shed and replaced about the time common for the change of the temporary for the permanent teeth; and the process appears to have been completed, except on the right side of the upper jaw, when the first molar, the two bicuspides, and canine failed to make their appearance. A blank space marked the spot these teeth should have occupied, and at the age of twelve became the seat of a hard painless enlargement of the maxilla, causing disfigurement of that side of the face, but no further inconvenience. The patient applied to Mr. Tellander in consequence of an attack of inflammation in the enlarged part of the jaw, resulting, as she supposed, from the presence of the roots of a temporary molar, which

in December last, for the first time, became painful, and from that time she dates the commencement of the present mischief. Mr. Tellander found considerable enlargement of the bone, with swelling of the contiguous soft parts, and a free discharge of pus from the gum about the roots of the temporary molar. These offenders were at once removed, and carious bone detected in the vicinity of their sockets. Three days subsequent to the first visit the diseased parts were again examined, and Mr. Tellander proceeded to remove the loose and carious bone which it was supposed formed the substance of the enlargement of the maxilla. It appeared under the probe to consist of large, hard particles of bone, amongst which the instrument might be moved, inclosed within a case of dead bone. After removing a few of these hard particles, Mr. Tellander found that he had come upon a cluster of minute teeth. The cavity was emptied, and the contents are before the Society. Mr. Tellander tells me that it is more than probable that some of the teeth escaped, and were lost before the nature of the case was detected; but here, independent of lost ones, we have no less than twenty-eight teeth or cusps attached and unattached. There are nine single teeth, each one perfect in itself, having a conical root with a conical crown, tipped with enamel. Again, we have six masses built up of adherent single teeth. Thus, one is composed of three united cusps; two

others are formed of two cusps each; a fourth is but an irregular mass of dental tissues; a fifth consists of three similar masses united by membranes. In the sixth mass no less than nine cusps may be traced.

The teeth, individually destitute of the normal form of any class of tooth, present the usual characteristics of supernumerary teeth, to which order they must be referred. But for their extremely small size and great number, the single teeth would not attract much attention. The compound masses in which the outline of distinct teeth can be traced, is a condition with which I am not familiar. Perhaps the nearest approach to this state of things exists in a case I have myself described, where a large mass composed of dental tissues irregularly disposed occupied the place of a second molar of the lower. A second and strictly similar case will be brought before the notice of the Society by Mr. Harrison. In each of these cases we have a dental mass larger in bulk than the tooth it represents or has superseded. It may be doubted whether the aggregate bulk of the supernumerary teeth in Mr. Tellander's case would equal that of the teeth of which they held the place. Upon this point, however, no positive opinion can be formed, for the history of the case is at present imperfect. In November, Mr. Tellander, before leaving for England, saw his patient, and took the cast of the mouth now upon the

table. It will be seen that all swelling of the jaw has subsided, and, what is more extraordinary, a tooth is making its appearance in the spot from which the host of teeth were removed. It yet remains to be seen how many and what kind of teeth will occupy the vacant space. As respects the general form of the jaw, and of the permanent teeth which have been developed, there is no departure from the usual forms.

That a tooth or teeth buried in the substance of the jaw should produce irritation, enlargement of the bone, suppuration, and exfoliation, is not an unusual, but it is not a necessary consequence of teeth so placed. There are preparations on the table which prove the one, and Mr. Tellander's case, and others having a less fortunate issue, might be cited proving the other position. A case, treated in the Middlesex Hospital, will serve as an example. In a female under thirty the lower jaw became enlarged and painful in the neighbourhood of the second molar, behind which an opening appeared giving exit to pus. A probe could be passed into a cavity in the bone, but the presence of a tooth could not be detected. An opening was made by a trephine, and the finger introduced, when a tooth, covered in great part if not entirely by membrane, was detected lying upon the floor of the cavity close to the lower border of the jaw. The tooth proved to be a perfectly sound wisdom tooth. Why in one case a buried tooth produces

so much mischief, and in another case remains through a long life a harmless occupant of the jaw, remains to be explained.

Shortly after the foregoing communication was read, Mr. Tellander presented the mass of teeth described to the Society. It has been deemed expedient to remove them from the spirits of wine in which they had been kept, to strip from them all the adherent fibrous tissue, and to mount them upon a card. From the teeth so placed the accompanying illustration, Fig. 20, has been taken. In

Fig. 20.

the upper line of figures, eight single teeth are shown, the ninth having been used for microscopic examination by our Secretary. In the second line the figures are taken from the six compound masses. The third line gives a series of minute teeth or such of dental tissue which were brought to light by the removal of the fibrous tissue amongst which they were previously hidden.

Within the last two months Mr. Tellander has forwarded to the Society a series of casts, taken from the mouth of his patient. They bear the following dates—February 4th, April 4th, and July 20th, 1863. They show a supernumerary and a bicuspid tooth emerging from the gum in the situation previously occupied by the growth of supernumerary teeth.

ANNUAL GENERAL MEETING.

Monday, January 5, 1863.

JOHN TOMES, Esq., F.R.S., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Mr. G. Ash, 26, Castle Street, Dover (non-resident).
Mr. J. R. Gurner, North Terrace, Adelaide, South Australia (non-resident).
Mr. E. A. Phillips, Batavia, Java.
Mr. J. Robertson, St. Margaret's Bank, Rochester (non-resident).
M. Versalovich, Corfu, Ionian Islands (non-resident).

The following Donation was made to the Society:—

By Mr. Tellander, of Stockholm.—A model of the mouth, and twenty-eight supernumerary teeth which were removed from the right side of the upper jaw, a description of which was given by Mr. Tomes at the last meeting.

The following Gentlemen were elected by ballot as Officers and Council for the ensuing year:—

President.—Samuel Cartwright, Esq.

Vice-Presidents.—Edwin Saunders, Esq.; T. A. Rogers, Esq.; W. A. N. Cattlin, Esq.; Robert Brookhouse, Esq. (non-resident); C. Spence Bate, Esq.; W. R. Bridgman, Esq.

Treasurer.—Arnold Rogers, Esq.

Librarian.—J. B. Fletcher, Esq.

Honorary Secretaries:—Foreign Correspondence.—Alfred Canton, Esq. *Ordinary.*—Alfred Coleman, Esq., and Charles Vasey, Esq.

Council.—J. R. Mummery, Esq.; W. A. Harrison, Esq.; J. D. Saunder, Esq.; G. A. Ibbetson, Esq.; W. Crampton, Esq.; C. J. Fox, Esq.; J. H. Parkinson, Esq.; N. Stevenson, Esq.; J. Sheffield, Esq.; G. Parkinson, Esq., Bath; R. White, Esq., Norwich; D. Hepburn, Esq., Edinburgh; E. Vizard, Esq., Scarborough; C. D. Rogers, Esq., Newbury.

GENERAL MONTHLY MEETING.

Monday, February 2, 1863.

SAMUEL CARTWRIGHT, Esq., President, in the Chair.

The following Gentlemen were proposed for the Membership of the Society:—

Mr. H. J. Perkins, 379, City Road.
Mr. K. Helfrich, 25, Notting-Hill Terrace, Bayswater.
Mr. J. A. Smith, 47, Smith Street, Chelsea.

The following Donation was made to the Society:—

By Mr. Truman.—The "Surgeon-Dentist's Manual," by Waite; and a "Dissertation on Artificial Teeth," by M. de Chemant.

Mr. Coleman exhibited a specimen of sacular disease on a first superior bicuspid tooth, alveolar abscess having existed in connection with the tooth. Mr. Coleman drew attention to the fact that the sac, which contained cholesterine and blood globules, was not the sac of the abscess. He believed the generally received view—viz., that the periosteum of the tooth became the sac in cases of alveolar abscess—was incorrect, in many cases the abscess being quite independent of the periosteum of the tooth.

Mr. Cattlin read a paper—

On Local Neuralgia Dependent on Diseased Teeth, illustrated by cases.

Mr. President and Gentlemen,—I propose to bring before the Society a few remarks on the dependence of neuralgia upon diseased teeth, and to illustrate some points of practice to which I am anxious to direct attention by a few selected cases. My chief object will be to promote discussion upon

the diagnosis and treatment of local neuralgia confined within the limits of Dental Surgery. I do not intend to enter into high scientific questions, such as the causes of referred sensation, reflex paralysis, &c., but merely to offer a few preliminary observations upon the pathology of the disease, and to lay before you the result of my own experience of its treatment. It is difficult to explain satisfactorily why exposure of the pulp to a current of air or any other source of irritation should in one individual produce a mild attack of toothache, and in another severe neuralgia. Perhaps the different degrees of pain which different persons suffer from the same cause may, in some instances, depend upon temperament, and in others upon the size of the nerves or the quantity of neurine they contain ; in like manner as intellect is supposed by some physiologists to be due to the comparative weight of the brain and the quantity of grey matter which enters into its composition. Again, we may draw an analogy between the pathological condition of teeth which occasion neuralgia, and that of other parts of the body which are particularly liable to a local form of the disease. Exostosis of the bones of the skull, angina pectoris depending upon structural cardiac disease, and sciatica arising from an inflamed condition of the neurelemma of the sacro sciatic nerve, will afford examples. I have seen cases of calcification of the pulp when only a small portion of

the membrane remained unossified and inflamed, in which it was quite possible to suspect such a condition by a peculiar violent darting pain suffered by the patient. The character of pain, the point at which it commences, and the course it takes, are at all times worthy of attention as means of diagnosis, although they cannot be relied upon as unerring symptoms of local disease. Before entering upon the subject of neuralgia dependent on diseased teeth, I may be allowed to refer briefly to some constitutional states or morbid conditions which have produced the painful affection of the face formerly described by Fothergill, and now universally recognised as tic douloureux. Inflammation, compression, or irritation of the neurelemma, or of the fibres of sensitive nerves, the presence of vitiated secretions or irritating substances in the alimentary canal, some morbid conditions of the blood, dyspepsia, local injury from cold or accident, congestion of the brain or spinal cord, fright, excitement, or depression of the nervous system, bodily fatigue, &c., rank directly or indirectly among the most common causes of facial neuralgia. Dr. M'Culloch has pointed out the influence which malaria exerts in producing the disease. At times it appears to be hereditary; and looking at the predisposing effect of gout and rheumatism, it is surprising that examples of this kind are not more frequently met with.

Sir Charles Bell believed the upper part of the intestinal tube to be the seat of many cases of tic douloureux, and was accustomed to treat it with marked success by repeated doses of croton oil. His object does not appear to have been merely to empty the intestines, but rather to stimulate the bowels and liver to evacuate their morbid secretions. He has quoted a very severe case which had endured for some years and was cured by this treatment. An ulcer was found in the ileum after death, but Sir Charles does not give a decided opinion whether the ulcer was the cause of the tic, or whether it was caused by the drastic purgatives used for its cure.

I am acquainted with a lady who for the past two years has occasionally had at irregular intervals violent paroxysms of pain in the inferior dental nerve. The pain commences beneath the ziphoid cartilage, and passes up the right side of the chest and neck to the inferior maxilla. The mucous membrane of the stomach and œsophagus is at times irritated by intensely acid secretions. She is of a rheumatic diathesis, and has suffered from attacks of sciatica. There are no decayed teeth in the lower jaw. A combination of carbonate of bismuth, bicarbonate of potash, and ether generally affords relief. Sir Henry Halford has published very interesting cases of tic-douloureux of several years' standing, some of which terminated in apoplexy. After death the frontal

and other bones of the skull were observed to be thickened and studded with irregular osseous growths. The most severe agony I have ever witnessed in the facial nerves, was suffered by a gentleman who had been thrown from his chaise on to his face. The nasal bones were fractured, and the soft parts bore marks of severe injury. Whether the cause was a spiculum of bone, hardened cicatrix, or some foreign body which entered the wound at the time of the accident, has not yet been ascertained. He suffered severely for upwards of thirty years, and died at last worn out by pain. Dr. W. Wood has recorded a case of unusually large neuroma of a nerve of the neck, which occasioned facial neuralgia; and Dr. Copland has referred to an example of pain in the frontal nerve, produced by the larva of an insect in the frontal sinus, which being ejected by sneezing, the patient at once recovered.

I have quoted the foregoing cases merely to show how various are the causes which may produce neuralgic pain of the face similar to that occasioned by diseased teeth, particularly in patients the tone of whose nervous system has been depressed, or whose general health has become depreciated. Perhaps it may be interesting to ascertain whether there be any one symptom or chain of symptoms by which local neuralgia dependent on diseased teeth can always be clearly distinguished from that form of the disease which

arises solely from constitutional causes? I firmly believe this question, notwithstanding the advanced state of knowledge, must be answered in the negative. Medicine is not an exact science; the natural history and pathology of many diseases have yet to be learned, and I know of none which requires more careful and accurate observation to detect its origin than the painful affection which now engages our attention.

Patients who suffer from constitutional neuralgia of the face often describe peculiar kinds of sensation, resembling the piercing of a red-hot wire, an electric shock, &c.; and a slight touch or current of cold air, the movements of the tongue or jaw in speaking or masticating, will often produce an attack. The pain frequently occurs in regular paroxysms, either commencing and passing off very suddenly, or is preceded by a feeling likened to the ticking of a watch, fluttering or painful pulsation. Nevertheless, it must be admitted that in shattered constitutions all these symptoms may attend strictly local neuralgia. Again, neuralgia may be of a mixed character—that is, arising from purely constitutional causes, which are aggravated by the irritation of diseased teeth, and exactly the reverse of this. In such cases, remedies will fail to afford more than temporary relief, unless both the local and constitutional causes are removed. A thin, haggard-looking woman, aged forty, suffered many years from constitutional neuralgia.

She could not bear the skin of the cheek to be touched nor cold air to pass over it; the symptoms were always increased by damp weather. She had exostosis in different parts of the superior axilla, and one by one the teeth became affected by the same disease around the fangs, the extremities of the roots being absorbed, probably from the pressure of bone deposited in their sockets. She had detected, by increased suffering, when a particular tooth had become diseased, with one exception. On that occasion, by her desire, at eleven o'clock in the morning, I extracted an upper central incisor, upon the understanding that it should be immediately returned to its socket if the fang was found to be healthy. These conditions she refused to comply with until half-past four in the afternoon of the same day, when, with more curiosity than judgment, I steeped the tooth in warm water, and replaced it in the jaw. Adhesion took place, and it became moderately tight. It was, however, under the circumstances, a hurtful source of irritation, and was extracted at the end of the sixth week. Bony growths and diseased teeth were from time to time removed from this patient, and a saturated solution of acetate of morphia in creosote was on four separate occasions applied in the vicinity of the infra orbital and submental nerves. It was curious to note that each operation gave relief for about three months, and then the paroxysms of pain returned with their usual force.

Quinine, in doses from 1 to 30 grains, sesquicarbonate of iron and powdered bark, belladonna, and morphia, in turn controlled the symptoms; but arsenic, after its cumulative property had produced the poisonous action of the remedy upon the stomach, throat, and conjunctiva, always arrested the disease, until some new source of local irritation occurred or the general health became again weak.

Enough has been said to show that the utmost discrimination will at times be required to distinguish when constitutional and when local causes operate to complicate any particular case. Disordered function or organic disease may be masked by the more prominent symptoms of pain, and more severe pain in a remote part may abstract the attention from that which is the real seat of the complaint.

Mr. Thomas Bell believed he had discovered a means of diagnosis between constitutional and local neuralgia in the periodicity of the paroxysms of pain. The theory that all cases of facial neuralgia are of constitutional origin, in which the paroxysms of pain are either of an intermittent character, or are regularly more severe at any particular hour, has, I think, been proved to be erroneous, and daily experience confirms that opinion. However, many intelligent practitioners still differ upon this point, and consequently it is not uncommon to meet with patients who have

been treated medically for many months without benefit, in whom the disease has at once been cured by the extraction of a tooth or of a small piece of dead bone.

Some of the cases which will hereafter be referred to support this assertion; and others will be quoted on account of the particular points of interest which they are intended to illustrate.

A gentleman, aged thirty-six, of the sanguine temperament, who had undergone excessive mental fatigue and excitement, to use his own words, "suffered torture from time to time, over a period of from two to three years. The pains were violent, extremely acute, passing from one part of the head to another, especially from the back of the head to the eyes, as if something were beating against them. At other times intense pain was fixed in one spot, or again it seemed to involve the whole head." The paroxysms did not at this time occur at regular hours, but generally while he was undergoing mental effort. The second right and left upper molars had been stopped five years before. He had experienced severe pain before they were plugged, which local and medical treatment relieved. He did not again suffer until two years and a half ago, when, the plugs being loose, were renewed by a dentist of high reputation, and the symptoms for a time passed away. On the 8th of April, 1860, he consulted me under the following circumstances:—For three months he had

endured violent neuralgic pain, which commenced in the left ear, extended to the palate, passed over the neck, face, and left temple, across the cheek, in the direction of the second upper molar on the right side. Of late the paroxysms of pain had every evening been indescribably severe, and medical treatment failed to afford relief. The second right and left upper molars were inflamed and moderately sensitive when rapped, particularly the left. A fistulous opening had been formed on the right side. There was slight tenderness of all the teeth in the lower jaw. The second right and left upper molars were extracted, and fœtid pus was found behind each stopping. The periosteum of the fangs of the right tooth was disorganised; that of the left side was inflamed and thickened. He was directed to take tincture of bark, with iodide of potassium, three times a day, and to recruit his health by rest and change of scene. All pain in the face ceased shortly after the teeth were removed, but he experienced aching pain in the back of the neck and across the shoulders for two days. On the 6th of January, 1863, he wrote, "Since the extraction of the teeth I have scarcely had a return of the pain; certainly not with any severity."

From the history of this case it is probable that, the teeth being sensitive, the first stoppings were or became imperfect; that there was, therefore, room for the pulp to swell, and for any

secretion to pass by the side of the amalgam. If no provision was made for the same conditions when the teeth were plugged a second time, it would not be difficult to account for the symptoms which followed. From the patient's own description it will be observed that the pains in the head for a long time were somewhat similar to those occasionally produced by an imprisoned wisdom tooth; that they came on soon after the teeth had been stopped a second time, and when the brain was excited or congested from overwork; and the pulp would, probably, participate secondarily in the congestion or excitement of the brain. The lancinating pains in the face and other parts which occurred latterly might either be due to inflammation of the pulp, or to inflammation of the periosteum extending to the neurelemma or substance of a branch of the dental nerve, aggravated by excitement or fatigue of the brain or nervous system. If teeth be stopped when the pulp cavity is exposed, perhaps it is desirable to provide for some swelling of the pulp or effusion of pus by the use of concave bone caps, and to remove the plug directly bad symptoms appear. Huhlien's operation does not often succeed when the fangs of a molar tooth are much inflamed. The length of time severe suffering was endured in the case just quoted fairly raises the question, how far should conservative dental surgery be carried? To preserve

teeth, as long as they can be made subservient to the uses of mastication and appearance, is undoubtedly the first duty of the dentist; but when they have become sufficiently diseased to affect the general health, or so painful as to interrupt the ordinary duties and comforts of life, the prevalent conservative dental surgery of the present day becomes mischievous; and although such practice may suit the feelings of nervous patients and timid operators, it is well calculated to reflect discredit on our art.

The next case of local neuralgia to which I shall refer was caused by acute periostitis of a sound tooth; the patient being a strong, healthy woman. Most parts of the face were affected by lancinating pains during the day, and every evening they occurred in such a severe paroxysm that the patient was obliged to be held in her chair. She had, for some time, been treated medically for neuralgia by a skilful surgeon without relief. All the teeth were perfectly healthy, with the exception of a sound lower central incisor, which was loose and acutely sensitive. She was not cognizant of having received any injury. The gums were freely incised with a bleeding lancet between all the lower incisor teeth; leeches were applied night and morning, and the patient was ordered to take two ounces of black draught every four hours until the bowels were freely purged. Under this treatment the inflammation

speedily subsided, and the neuralgic pains did not recur.

Crowded or loose teeth sometimes occasion irritation, and cause or keep up facial neuralgia.

The patient from whom the specimen of exostosis, Fig. 21, was taken, was at once relieved of neuralgic pains, which had baffled physicians for many years. There was a little dulness on percussion, but the tooth was only, at times, slightly sensitive. An attack of neuralgia followed a particular examination, which pointed out the cause and led to its removal.

Fig. 21.

The canine tooth, Fig. 22, the fang of which, when extracted, was almost as sharp as a needle, gave rise to irritation of the nerves of the face, which subsided upon its extraction. A correct diagnosis was made in this instance by causing the patient to bite upon a hard substance. Fig. 23, is an example of the crown of a third lower molar lying upon the nerve of a second molar, after it had, by pressure, produced absorption of its fang. (The teeth were exhibited, and also represented by diagram.) Many causes of neuralgia may be *concealed*, and, unless care be taken, they are apt to escape notice. A knowledge of the facts that inflamed teeth of the inferior maxilla commonly produce what is inde-

Fig. 22.

Fig. 23.

finitely called sympathetic pains in the neck, ear, or shoulder, those of the superior maxilla generally affecting the face and temple, while the teeth of both jaws sympathise with their antagonists, will serve to guide our examinations and to assist the diagnosis.

Sometimes a diseased fang will be covered by healthy gum, without the slightest fissure or morbid appearance being observable to indicate its position. At other times the exciting cause will be found in a cavity concealed between the teeth, by the side and below the gum, or behind a wisdom tooth. Occasionally a whole set of apparently healthy teeth will be more or less affected by exostosis or absorption of their roots; and sometimes, late in life, a tooth of the second set will become imprisoned beneath the crown of one of the first set. Again, irritation may be caused by the irregular pressure of an artificial piece. I once saw a patient who had been taken to Mr. Paget as a case of ranula, in whom a gold plate had buried itself beneath the soft parts of the tongue. A diseased tooth which is only slightly painful may be the source of severe pains either in adjoining teeth or in teeth situate even in a remote part of the other maxilla.

Perhaps chronic neuralgia (if I may be allowed the term) is more frequently derived from a thickened condition of the periosteum of fangs, the extremities of which have been absorbed, or

around which there exists a deposit of new bone to a greater or less extent. The roots of such teeth often present a rough irregular surface, and sometimes have granular fleshy tumours, or spiculæ of sharp bone, projecting from them.

Figs. 24 to 31 represent the fangs of teeth in these conditions.

Fig. 24.

Fig. 25.

Fig. 26.

Fig. 27.

Fig. 28.

Fig. 29.

Fig. 30.

Fig. 31.

The two following cases will illustrate the foregoing observations:—In November, 1848, a domestic servant, aged 19, complained of a constant gnawing pain on the right side of the superior maxilla, which generally extended from the upper central incisor to the second molar, with frequent lancinating pains, which darted across the palate into the throat and along the root of the tongue. These pains had gradually increased for five years; they were always worse at ten o'clock in the evening, and sometimes during the whole night. The chief pain being now referred to the first molar, it was extracted, and all its fangs were found to

be absorbed nearly to the crown. Considerable hæmorrhage followed, which lasted six hours, and was arrested by compression with sponge. The teeth on the right side continued sufficiently tender to prevent mastication, but her sufferings were relieved for about four months. She again applied for assistance on the 1st of May, 1849, and the pain was now referred to the right upper central and lateral incisors, the crowns of which were diseased. They were extracted, and their fangs, like the others previously mentioned, were also absorbed. About four years ago she received an accidental blow in the mouth, which loosened the front teeth on the right side and caused considerable inflammation. On the 10th of May the pain was slightly relieved by the previous extractions, but was still referred to the right side. The left incisor and canine teeth are decayed and loose, evidently from absorption also of their roots. No pain is produced by striking any of the upper teeth, but they are tender when pressed laterally. The eruption of a wisdom tooth on the right side of the lower jaw will account for the lancinating pains which are felt in the tongue, throat, palate, and right ear. Free crucial incisions were made through the gum over the right lower wisdom tooth; and her health being impaired, she was ordered to take tincture of bark, with nitric acid, thrice daily. She received temporary relief from this treatment, but was not permanently cured of

neuralgia until every diseased tooth had been extracted. The fangs of all the teeth which were removed (ten in number) were more or less absorbed; some were also thickened by bony deposit, and were rough at their extremities.

The second case was the wife of a clergyman who resided in a damp cold district of Wales. This patient suffered from neuralgic pains in "every part of the face, head, and ears, which passed from tooth to tooth, and increased in severity at night." A number of teeth were decayed and tender; she was seldom able to masticate comfortably. Her rest was disturbed, and her general health had become extremely bad. She had nearly lost her life from shock when a tooth was extracted on a former occasion, and the pulse was at this time scarcely perceptible at the wrist from the effect of fear. Stimulants were administered again and again, and eight teeth were extracted while the patient was thoroughly under the influence of wine: their periosteum was thickened, and small granular tumours, the result of chronic inflammation, were found at the ends of the fangs. From this time the pain ceased, and her health was restored by generous diet. Neuralgia may be produced by dental operations upon a highly sensitive person; and here again true stimulants in large doses are the best remedy. Some years ago I extracted without difficulty an upper molar tooth for an intimate friend, a strong

man in excellent health, but of remarkably sensitive feelings. Shortly afterwards, while joking about the pleasantness of the operation, he suddenly fell, literally writhed with agony, and was unable to speak for about ten minutes. Half a tumbler of brandy was administered, and he as suddenly recovered. I was then for the first time informed that he had suffered similar paroxysms after operations by Mr. Cartwright, sen., and the late Mr. Nasmyth; but in both instances the teeth were extracted in the morning, and the neuralgic attack did not come on until the evening. I have since removed several teeth from the same patient, having first obliged him to drink nearly a bottle of port wine, and have been gratified by finding that I thereby prevented an attack of neuralgia. Time will not allow me to refer to more than one other case which illustrates the effect of a diseased tooth upon a nerve of sense. In the month of September, 1843, a lady in the second stage of consumption consulted me concerning a diseased right lower molar. She had for about three months suffered acute pains in the tooth, ear, and side of the neck. When I saw her, she had become deaf for four days. The inflamed tooth was extracted, and hearing returned within an hour after the operation. Can the case I have just quoted be referred to reflex paralysis? I think it admits of no other explanation. Without digressing into the discussion of this subject, we

have here a practical proof that the irritation of a diseased tooth may occasion deafness.*

The remarks which have hitherto been made have generally referred to cases of facial neuralgia, in which extraction of *all* irritating teeth was a successful remedy after medical treatment had signally failed. We are, however, frequently called upon to treat patients who refuse to submit to an operation, or where the disease involves one or more teeth which, between the attacks of neuralgia, are useful for mastication or appearance. When the pulp is exposed and the fangs are not inflamed, if a saturated solution of acetate of morphia in creosote, or solutions of mastich, tannin, and other astringents or sialogogues, do not arrest pain, the pulp may be destroyed by the electric cautery, escharotics, &c.; or, when the cause is in the periosteum, local depletion and those remedies which improve the digestion and general health offer the best prospect of relief. I have often traced a connection between inflamed teeth and acid secretions in the stomach, and particularly in persons of a rheumatic diathesis. Antacid and drastic purgatives, quinine, hydrochlorate of ammonia, iodide of potassium combined with the bicarbonate, powdered bark, sesquioxide of iron, morphia, and arsenic, are each, if judiciously administered, useful remedies.

* A similar case is quoted by Mr. Tomes in the "British Journal of Dental Science," vol. vi. p. 73.

Benefit has been derived from electricity, the inhalation of chloroform, counter-irritants, &c. The local application of fresh extract of belladonna, or a narcotic liniment composed of equal parts of tincture of aconite, chloroform, and tincture of opium, seldom fail to afford temporary relief.

Fig. 32.

Irritation is sometimes prevented by protecting the pulp from pressure with a gold cap in the manner represented by this example, Figs. 32 and 33; and when the patient clenches or grinds the teeth during sleep it is almost impossible to cure inflammation of the fangs

Fig. 33.

unless some such contrivance be applied over the grinding surfaces of one or two healthy molars. The number of cases which have been quoted in the course of this short and imperfect paper have been introduced upon the principle that example is better than precept. Cases, when they are faithfully recorded, illustrate the symptoms, causes, and treatment of disease more practically than elaborate arguments.

GENERAL MONTHLY MEETING.

Monday, March 2, 1863.

SAMUEL CARTWRIGHT, Esq, President, in the Chair.

The following Gentleman was proposed for the Membership of the Society:—

Mr. C. West, 9, London Terrace, Hackney Road.

Mr. J. Walker read a paper—

On Exostosis: its Pathology and Diagnosis.

Mr. President and Gentlemen,—On showing one or two specimens of Exostosis that I have before me to our worthy Secretary, Mr. Vasey, a few months since, he expressed a wish that I would consent to write a short paper on Dental Exostosis, with the history of as many cases as I had recorded.

To this request I acceded, but offer the few following remarks with some amount of hesitation, as I cannot present to your notice any new facts, or very rare specimens; but my desire to render any service I can to a society in which I take so deep an interest, and one in which I feel the general good of the profession is so intimately bound up, has overcome any scruples I may have felt in trespassing on your time.

Exostosis.—By the term *exostosis* should be

understood a purely bony mass set upon a bone, forming with it an organic whole, and, where it is possible, originating or proceeding from the bone. When its development is complete, and often at the beginning of its growth, its texture is always homologous with that of its base and point of origin, whether it be compact or spongy. Hence all new growths upon or within a bone which hold any other relation to it are excluded, although they may be more or less composed of such texture altogether. Bony growths which proceed from the periosteum, but sooner or later become united with the bone, are admitted.

Exostoses are composed sometimes of compact, sometimes of spongy bony substances, although some are made up of both of these substances. In dental exostosis we find specimens of both of these classes, ivory exostoses being the more frequent. The Figs. No. 34 to 38, and these

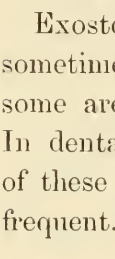


Fig. 34.

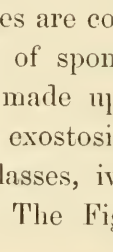


Fig. 35.

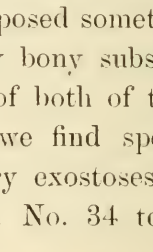


Fig. 36.

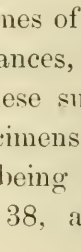


Fig. 37.

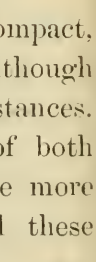


Fig. 38.

specimens, show the varieties and nature of the deposit upon the fangs of teeth. You will observe they present great difference in the arrangement of the layers of new bone, sometimes

entirely encircling the ends of the fangs:—this may be called "Periostosis,"—and in other instances, as if the new deposit had been poured upon and glued to the surface of the fang.

Again, small nodules are found attached by a narrow base to different parts of the surfaces of the fangs, and even to the crown portion of the tooth. The diagram No. 5 is taken from a specimen in the museum of the Royal College of Surgeons.

The new growth, to all appearance, has the same characters as the enamel covering the lingual surface of the crown. The diagram No. 6 is taken from this specimen. Few, I think, will hesitate to admit that it is another specimen of the same type as the one just referred to, only the new growth is deposited partly on the enamel and partly on the fang.

The other class of Dental Exostosis that I have alluded to, is the spongy.

The new growth of bone constituting spongy exostosis is sometimes observed upon the articulating surfaces of the alveoli. These abnormal growths are much more rare than the preceding, and may with propriety be named enostosis. The microscopic characters of this new deposit of bone on the teeth I shall not speak of this evening; the subject was so ably treated by the late Mr. Hubert Shelley, whose paper on Dental Exostosis most that are present here this evening heard read. It

is published in the first volume of the Transactions of the Odontological Society.

In searching for a cause of exostosis, we think that inflammation of the peridental membrane must be regarded as the first step in the morbid process; that inflammation giving rise to an exudation of lymph of a sufficiently plastic character to be organized into fibrous and then into osseous tissue. When the lymph has not this plastic or organizable character, but is of a lower form, approaching in its microscopic characters to pus, the same inflammation of the peridental membrane may give rise to alveolar abscess. The circumstances which determine which of these two results is to follow the one cause, I take to be the degree or intensity of the inflammation and the state of the constitution at the time.

If the inflammation be great, and the patient in feeble health, we should expect abscess; if, on the other hand, the inflammation be more chronic, and the patient in good health, the result would be exostosis. That inflammation of the peridental membrane occurs in various degrees, may be gathered from an examination of cases occurring in daily practice. I refer to those cases where the peridental membrane comes away with the fang when the tooth is extracted. This it is well known frequently occurs, and the explanation I would offer of this fact is the following :—

Inflammation has taken place, lymph has been

exuded between the peridental membrane and the periosteum which lines the socket. This exudation has loosened the connection of the former structure with the latter, whilst its adhesion to the fang is but little diminished, and hence it comes away. When subsequently it will be found to present various degrees of thickness, in one case the membrane will be merely vascular and but slightly thickened; in another its thickness will be considerably increased; and in this specimen which I submit to your notice, the structure is converted into a dense fibrous layer surrounding a good part of the fang, and having the appearance of a little tumour connected with the bone, and which, in all probability, if allowed to remain longer in the jaw, would become converted into osseous tissue. That it is really an altered state of the peridental membrane is, I think, proved by the fact, that on carefully separating this fibrous tumour from that portion of the fang which it surrounds, no other membrane whatever answering to the peridental membrane can be found.

It is frequently thought that when tumours of this description are met with, they are the remains of the sac of an abscess. I am not prepared to deny that this may sometimes be the case, but in the instance from which this specimen is taken there never were any indications of abscess. The symptoms were chronic pain with sponginess of

the gums; the subject a man of general good health, aged 30.

We find Virchow, in his "Cellular Pathology," refers to what we consider to be similar tumours occurring in connection with the socket; and by your permission I will read his description of an interesting one occurring in the jaw of a goat.

The specimen alluded to exhibits, with a distinctness which I have rarely witnessed, the transitions from periosteal connective tissue into osteoid tissue, and this too with a modification, inasmuch as calcification has not taken place in large portions of the parts which already possess the structure of bone.

Networks of osteoid trabecula, with jagged cells, enclose primary medullary spaces filled with fibrous connective tissue.

This preparation comes from a tumour in the jaw of a goat, and contributes towards our knowledge of the transitions from connective tissue into osteoid tissue about the same information that the history of rickets has supplied us concerning the transformation of cartilage.

The tumour which affected the superior and inferior maxilla, but each separately, has such little density that it can be cut with great facility, and only in a few places does the knife meet with greater resistance.

On making thin sections, we see even with the naked eye that more or less dense portions

alternate with each other, so that the whole has a reticular appearance. When examined under the microscope with low power, it is at once perceived that the disposition of the constituent parts is entirely that of bone. For primary medullary spaces and trabecula network alternate with each other, just as if the observer had before him the medullary spaces and trabeculæ of a spongy bone. The substance which forms the trabecular network is on the whole dense, and is therefore readily distinguishable, even with a low power, from the more delicate substance which is enclosed by the trabeculæ, and fills the cavities of the meshes. This structure exactly corresponds to that which we have seen in the development of bone from periosteum; it is the plan followed in the growth of bone in thickness.

Wherever young periosteal deposits are examined, there is found in the meshes of the network formed by the osteoid substances, this primary marrow containing fibres but no cells, as is the case at a later period.

This primary marrow consists of the remains of the periosteum itself (after its prolification) which have not yet undergone the transformation.

The transformation into osteoid tissue advances into the proliferating periosteum in the first instance always in such a way that the fibrous tissue becomes condensed, though only partially so, the condensation beginning at the bone and

proceeding outwards in certain directions. In this way there arise at first (resting like columns upon the bone) hardish cones, which are united by transverse bands parallel to the surface of the bone, and thus constitute this network.

Now if acetic acid be applied to these parts, we see at once that the whole fibrous mass which fills the alveoli contains the most wonderful connective tissue corpuscles, which are so arranged that next to the trabeculæ all around they lie in connective rows; whilst in the most internal part, the marrow, they constitute stellate corpuscles anastomosing with one another; but that in some parts the trabeculæ have already become true bone where calcareous salts are really deposited in them. Whilst the periphery of such calcified trabeculæ offers a brilliant, almost a cartilaginous appearance, in their middle an opaque, finely granular matter presents itself, which pervades the intercellular substance, and towards the interior of the trabeculæ passes into a nearly homogeneous calcareous layer, in which at intervals the osseous corpuscles may be recognised.

Here we have already a complete osseous network, and at the same time an exact picture of the regular growth of bone in thickness. If, however, the spots are very carefully examined where the borders of these trabeculæ and bands of bone come into contact with the fibrous substance of the meshes, it is seen that no perfectly defined limit

exists there, but the intercellular substance of the osteoid tissue is gradually lost in the intercellular substance of the fibrous marrow; so that here and there a few of the connective tissue-corpuscles of the fibrous connective tissue are included in the sclerotic substance of the trabeculæ.

Hence you may infer that the formation of real osseous substance from connective tissue is essentially effected by the gradual change of the intercellular substance, and that this loses its original fibrous nature and becomes converted into a dense, shining, cartilaginous mass, without its ever really attaining to the structure of cartilage.

Here there is never a stage exactly corresponding to any of the known forms of cartilage, but it is out of connective tissue that we see the osteoid substance directly arise, which in cartilage also is the first to arise when it becomes bone. Cartilage, as such, can only calcify when it is to become bone; a transformation of its tissue must take place, the chondrine-containing basis substance must be converted into a gelatinous-yielding intercellular substance.

The next question which presents itself is, what are the principal causes of inflammation of the peridental membrane?

Of these, caries must be regarded as the chief, and to this I would add concussion, apparent elongation from the rising of the tooth in the

socket, rheumatism, syphilis, gout, and mercurialism.

I have examined a considerable number of teeth lately (about 10,000), both diseased and sound, with the object of ascertaining the relative frequency with which exostosis occurs in different teeth and at different ages :—

Carious Teeth, 6,200	319	Exostosed.
Sound Teeth, 3,000	85	„

With regard to carious teeth, of which I have examined about 6,000, I find the relative frequency to be as follows :—

1st. Molars, in 4,000	210	Exostosed.
2nd. Bicuspids, in 2,004	94	„
3rd. Incisors and Canines, 200	10	„

Sound teeth, of which I examined about the same number, may be divided into two classes: viz., 1st, those extracted from subjects over thirty years of age; 2nd, those from subjects under thirty years of age.

1st. In Bicuspids, 688	27
2nd. Molars, 258	8
3rd. Incisors and Canines, 2,166	50

Of the 2nd Class :—

1st. Molars, 200	5
2nd. Biscuspids, 500	12
3rd. Canines and Incisors, 1,000	20

It will be observed in these tables that exostosis is at all times least frequent in the incisors and canines. Why exostosis is more common in carious molar than in other diseased teeth I

know not, unless it be from the greater extent of membrane which surrounds the three fangs, and from that structure being peculiarly pressed upon at the angles formed by the bifurcation of the fangs and the greater amount of force brought to bear on these teeth in the act of mastication, causing in the course of time a degree of looseness of the teeth in the socket.

Why in the second class of sound teeth the bicuspids are most frequently affected I can offer no satisfactory explanation. I have here five specimens (Figs. 39 to 43), which were extracted

Fig. 39.

Fig. 40.

Fig. 41.

Fig. 42.

Fig. 43.

from the upper and lower jaw of a patient some time since. In these I find hypertrophy of the entire fangs of four teeth ; the other, the wisdom, is exostosed on each fang. Some hold the opinion that no hypertrophy can take place in the fangs of teeth, but certainly in these specimens a difference is manifest between the ordinary exostosis and the condition of the fangs of the other four teeth. The particulars of this case are rather interesting. The patient was a surveyor under Sir Morton Peto; he was out of reach of any medical assistance for three years, and during

that time had suffered from continual neuralgia, and had frequent attacks of acute inflammation, resulting many times in abscess.

On requesting him to describe his sufferings, he said they had been manifold, evidently those of acute and chronic inflammation, with extensive swellings and suppuration; besides these a sensation at times as if the jaw was being split into pieces.

In the extraction, under the influence of chloroform, of the remains of several teeth and the teeth Figs. 39 to 42, he was free from pain for a few days, but the pain peculiar to exostosis returned. The dens sapientiæ was then removed, which gave him entire relief.

This case proves that long-continued irritation and inflammation of the pulp of the teeth is a cause of exostosis. In the wisdom tooth, we see also that exostosis may be present although the tooth be sound. The chronic inflammation appearing to extend to the peridental membrane of the adjacent teeth, layers of new bone are deposited upon them.

From the appearance of these specimens no such conclusion can be arrived at. The teeth are perfectly sound; no discoloration of crown or fang, but evidently possess that pearly whiteness peculiar to certain classes of healthy teeth. The deposits of new bone in these teeth are types of all cases of exostosis found on sound teeth.

The deposit is always much less in substance and quantity than in carious teeth. I know of no reason yet assigned why the peridental membrane should become the formative membrane of this new deposit and then entirely to cease its active condition, which evidently must be the case, from the fact that the deposit is always so circumscribed and so small in quantity, unless from some constitutional affection setting up inflammation in the peridental membrane for a short period, the deposit of bone being the result of that inflammation. Of the constitutional causes of these attacks of periostitis, I believe rheumatism to be the most frequent. It is proved that rheumatism affects all the fibrous tissues of the body. The valves of the heart, and particularly their edges which possess more fibrous tissue, are a good example. We have some peculiarity in the structure of the periosteum: it is fibrous in nature and very vascular, and of this circumstance we are in the habit of taking advantage by rotating teeth either at once or by gradual pressure to rectify malposition, without loss or injury to the tooth.

If the peridental membrane can be shown to possess the function of the new formation of bone without the necessary production of cartilage, then I can see no reason why the inflammation of the periosteum produced by rheumatism may not induce the condition of exostosis. That the peridental membrane and the periosteum of the teeth

and jaw are affected with inflammation during atacks of rheumatism, I was assured by Dr. Goodfellow and Dr. Corfe, both having seen many cases of periostitis in attacks of rheumatism. From my own personal observations I am strongly disposed to think that not only periostitis may be present in the dental periosteum when rheumatism exists elsewhere, but that it is peculiarly liable to rheumatic inflammation, and may be present without any concomitant rheumatism in other parts, just as we may have rheumatic iritis without any other manifestation of the rheumatic diathesis.

One chief reason for entertaining this opinion is the very decided relief which is frequently observed to follow the use of iodide of potassium in cases where with tenderness of one or more of the teeth there has also been severe and long-continued pain about the jaws and face, cases which are frequently described as purely neuralgic.

In such cases we have repeatedly observed that morphia administered through the mouth and also by sub-cutaneous injection close to the seat of pain, quina, iron, leeches, blisters, and all the other remedies recommended in neuralgia have failed to give relief, yet the iodide of potassium in doses of about three or four grains, say given every six hours, has soon subdued the pain, and that permanently.

Syphilis and gout we also consider to be predisposing causes of exostosis. I think so from

analogy in the effect of these diseases on other bones—viz., the production of nodes. But the nodes found on teeth which are attributed to syphilis differ somewhat in shape and appearance from that generally known as exostosis, as shown in Fig. 44.

Fig. 44.

We will now pass on to the last division of our subject—viz., the diagnosis of exostosis from other diseases.

We are all well acquainted with the peculiarities of the pain attendant upon this disease. It is generally described by the patient as splitting or expansion of the jaw. The constant pain during the deposit of bone while the absorption of the sockets is proceeding, produces pressure upon the nervous filaments of the lining membranes, and thus produces pain.

The most frequent cause of anxiety to the practitioner is the difficulty of diagnosing between a true case of exostosis and neuralgia. This is rendered obscure when the deposit of bone is developed in sound teeth and in very small proportions. The most faithful guide, in my opinion, is, that in neuralgia we find the pain intermittent, at times more intense and acute, affected by atmospheric influences, increased by anxiety and distress of mind, by the general conditions of the system; while, on the other hand, however small the deposit, the pain is constant with no intermission,

uninfluenced by sleep, rest, or the administration of narcotics, anodynes, or tonics.

The following is the history of a case that has given me great anxiety during the last six months. We were consulted by a patient who had suffered severe pain in the head and neck for several years; she assured me that for the last two years she knew not what a good night's rest was.

On examining the mouth we ascertained that the entire set of teeth was extensively diseased, only five crowns standing. She had consulted many medical men and had persevered with the remedies prescribed, but with no relief. On informing her that I could be of little service to her without she consented to the extraction of the fangs and the diseased teeth, after consultation with her medical man, she consented to this operation, protesting against the use of chloroform. I extracted the various fangs and teeth, making in all about thirty-five operations. I accomplished this in several visits, extracting the fangs of the right side upper, and then at the second operation the fangs of the right lower, allowing an elapse of time varying in duration between each operation. I was encouraged to proceed by the cessation of pain in that region after a lapse of a few days. This course was pursued until all that could be seen or discovered by ordinary probing were removed. After the last had been extracted and a few days allowed for the effects of

the operation to pass away, she was for several weeks free from pain, and we were congratulating ourselves on having accomplished a most difficult task; but, to my intense mortification and her great grief, she returned to me, after an absence of a short time, with the intelligence that her pain had returned and was even more intense, severe, and constant than before, but confined in particular to the sides of the head; her sleep was again disturbed, and the pain had no intermission.

I wrote to her medical man, entreating him to administer morphia and iodide of potassium, which he did, also the combination of quina and iron. Neither of these remedies gave relief.

After a very close examination I discovered a small dark speck in the situation of the first molar on each side: on taking a very fine probe a small sinus could be traced extending deeply into the alveolar socket; the gum appeared healthy. On dissecting a small fleshy substance that filled the upper surface of the socket, I could discover with the probe a roughened surface, and with difficulty we succeeded in bringing away a small piece of fang with exostosis at its extremity. A similar operation was performed on the other side of the lower jaw with like results. The Figs. 45 and 46 are correct representation of the two fangs. And it is pleasant to be able to state the operations have

Fig. 45. Fig. 46.

proved successful. Last week I saw her much improved in health, strength, and general condition.

The Figs. 47 to 51 represent these specimens,

Fig. 47.

Fig. 48.

Fig. 49.

Fig. 50.

Fig. 51.

kindly lent me by Mr. Gregson, who has given me the history of the case.

He was consulted by a lady who was then living some distance from town. She had suffered from severe neuralgic pains in the head and neck for more than two years; but these pains were frequently inexplicable for true neuralgia or acute toothache. If you notice, the canine tooth of the right side is decayed, and so was the left, but it has been mislaid. Mr. Gregson informs me they were extracted at the first interview: a short cessation of pain was the consequence; but very shortly her pain returned, with this difference, that the pain was much subdued, but constant—no intermission either night or day. At the second visit it was determined to extract the remaining four front teeth. These operations gave her perfect relief, and in a few months, from having all the appearance of a debilitated woman, she became hale and strong.

The four front incisors, on close examination, present peculiarities each somewhat differing from the other. The two laterals present the appearance that slow absorption of the immediate apex of the fangs was progressing; that in the left front a similar process was going on; but that in the right front absorption at the apex and deposit of new bone were being developed upon the lateral surface of the fang.

In this specimen there is evidence of absorption of the fang, and we think both induced by the same cause. I account for it by the supposition that there was exostosis of the alveolus, which I have before spoken of as enostosis.

That constant pressure from within will produce absorption, and occasional pressure from without will produce hypertrophy, is an old favourite theory of John Hunter; and we have frequent illustrations of this condition of things in the absorption of the vertebral column by the pressure of an aneurism of the aorta, or the absorption of the bones of the face from the growth of a polypi.

Fig. 52.

The Fig. 52 is a sketch of this specimen of anchytosis. It was extracted from the upper jaw of a man about forty. He had been treated for neuralgia for many months; his sufferings were very acute and without intermis-

sion. The surgeon in attendance considered it to be neuralgia or exostosis of the teeth. The man was unwilling to have the sound molar teeth removed, and suffered for a very protracted period. Eventually suppuration ensued, when the pain became so intense that the patient was induced to allow of their removal. The appearance of the two teeth precludes the necessity of dwelling upon this case; it only indicates that interrupted or suppressed irruption of the permanent teeth will induce a class of symptoms resembling somewhat the character of those present in exostosis. The suppuration was the diagnostic sign in this instance that it was not exostosis, as that is a rare result of that disease.

This specimen, the head of a monkey, was kindly lent me by Mr. Flower, who succeeded Professor Quekett as Conservator to the Museum of the Royal College of Surgeons. It is a specimen of true hypertrophy of the cancellous structure of the alveolus of the maxillary bone, and other bones of the face.

This hypertrophy is considered to be dependent upon the nervous irritation produced by the disease in the canine tooth.

The owner of the monkey, to prevent injury to himself or friends, broke off the crown of the canine, most probably giving rise to intense pain, suffering, and disease. If you notice, the hypertrophy is confined to the bones peculiar to the

face, those supplied by the fifth and seventh pair of nerves.

This case, if occurring in a human being, would most probably have given rise to great perplexity, and it is interesting in so far showing that from the irritation of a diseased tooth not only may bone be deposited upon the fang of the tooth itself, and other teeth, but extend to the maxillæ and other bones of the face.

Another disease with which exostosis may be confounded is incipient disease of the temporal bone from otitis. The chief means of distinguishing these will be in the character of the pain, which in otitis is always augmented by pressure about and behind the ear, and by movement of the lower jaw. Hearing will also generally be more or less impaired or confused. After a time, varying much in different cases and depending most on the degree of acuteness of the inflammation, the diagnosis will be complete by the discharge of fluid from the meatus, at first thin and watery, and then purulent. With this discharge the pain usually abates, unless indeed the inflammation extends also to the internal ear, when the symptoms will be both more severe and of longer continuance.

I have lately had a case in which I was tempted to remove the wisdom tooth, but feeling some doubt as to its being the real cause of the symptoms present, delayed for a time, and the

case turned out to be disease of the temporal bone. Suppuration took place just behind the ear. The probe could be passed in to the extent of $1\frac{1}{2}$ inch. After about two months' discharge of the purulent fluid, a piece of necrosed bone was detached, after which the part healed.

In another case under treatment at the same time, and presenting similar symptoms—but with this great distinction, that the pain, although it increased as night approached, yet was not increased by pressure about the ear,—the pain was entirely removed, and with it the complaint, by the use of iodide of potassium, after tonics and sedatives had failed to give relief.

With the history of these two cases I conclude my paper. I again desire to express that it was with great diffidence I undertook to prepare it, and must thank you for the kind attention you have given me while reading it.

GENERAL MONTHLY MEETING.

Monday, April 6, 1863.

SAMUEL CARTWRIGHT, Esq., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Mr. R. Helfrich, L.D.S., 25, Notting Hill Terrace.
Mr. J. A. Smith, 47, Smith Street, Chelsea.
Mr. H. J. Perkins, 379, City Road.

The following Gentlemen were proposed for the Membership of the Society:—

Mr. J. B. Bell, M.R.C.S., L.D.S., 30, Margaret Street.
Mr. R. Forward, L.D.S., 3, King's Terrace, Southsea.
Mr. H. R. Rowe, L.D.S., 60, Fishergate, Preston.
Mr. J. Steele, L.D.S., 63, High Street, Croydon.
Mr. G. Walker, L.D.S., 62, Ship Street, Brighton.

The following Donations were made to the Museum and Library of the Society:—

By Mr. James Parkinson.—"Observations on Surgery;" "Recherches, &c., sur l'Art du Dentiste," par M. Bourdet, 2 vols.; "The Art of Surgery," by David Turner, 2 vols.; "Cases of Neuralgia," &c, by G. B. Hutchinson; "Anatomical Exposition, &c., of the Human Body," by G. Douglas, M.D.

By Mr. E. Parkinson, of Brighton.—Model of an upper jaw, showing the canine tooth between the bicuspids; also an upper molar tooth with four fangs.

Mr. Orphoot, of Edinburgh.—Model of lower jaw, two extra bicuspids, and two extra-sized bicuspids.

Description of a Remarkable Case of Exostosis.

By J. Tomes, Esq., F.R.S., &c.

The remarkable specimen of exostosis which I have undertaken to describe has been placed at

my disposal by Mr. Hare, of Limerick, with the suggestion that the Museum of the Odontological Society might be a fitting place for its deposition. In Mr. Hare's name I beg to present it to the Society.

The following short history was received with this specimen:—The tooth, a molar, was taken from the upper jaw of a countryman, forty-one years old, who for some years previously had suffered severe pain in the jaw. The cheek was perforated by a canal through which matter constantly poured. After the removal of the tooth the pain in the jaw ceased, and the wound in the cheek healed. The accurate life-size figure of the tooth, (Fig. 53), executed by Mr. Bagg, will render any very detailed description needless. But attention may be directed to the following facts:—The conformation presented by the crown of the tooth deviates somewhat from that which would be regarded as characteristic of an upper molar. The number and the relations of the roots of the tooth are obscured by the mass of cementum by which they are surrounded. The mass itself may be roughly described as built up of three coalescing flattened lobes, not very distinctly marked: one immediately investing the roots of the tooth and composed of dense cementum; a

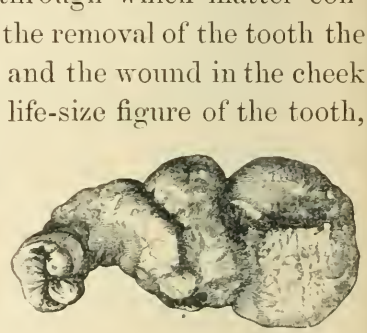


Fig. 53.

second continuous with the first, marked by abrasions produced by superficial absorption of the tissue, and presenting an appearance of less density than the preceding lobe. The third and terminal division is double the size of either of the preceding portions of the tumour. It is perforated by two irregular holes, one from either side, which lead to a large cavity in the centre, so large that the lobe might be regarded, were it detached from the tooth, and from the two lesser divisions of the mass, as an ossified cyst.

The tumour is not less than four times the bulk of the tooth to which it is attached, and the general form and position as regards the crown of the tooth justify the opinion that the cavity of the antrum must have been occupied or obliterated by the presence of the tumour.

I know of no specimen of exostosis in the human tooth which will compare with the subject of the illustration. My own collection contains a molar tooth of the horse from the posterior surface of which a mass of cementum has been developed three or four times the bulk of the tooth itself. This preparation and the one presented to the Society by Mr. Hare may be regarded as the most remarkable examples of dental exostosis on record.

The following paper was read by C. Spence Bate, Esq., F.R.S.

On the Treatment of Inflamed Dental Pulp.

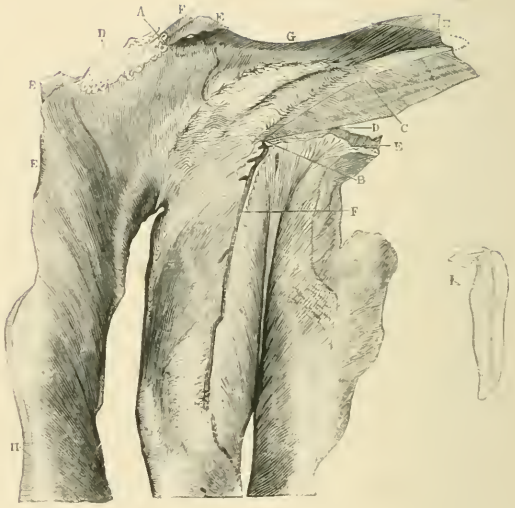
Ever since the surgical treatment of the teeth has been conducted upon the principles of science, the foremost effort has been to reduce an inflammatory action existing in the pulp of a tooth so as to enable it to recover its healthy condition.

The treatment which has been considered as the most desirable to pursue has been that of stimulating the dentinal pulp to continue its normal condition as a developing organ, and so, by building up fresh osseous tissue, to increase the quantity of the dentine between it and the external injury, while at the same time the pulp itself being diminished in size, becomes therefore more subservient to remedial agents.

That the dentinal pulp has very extensive powers of repair has repeatedly been demonstrated both in animals and man. Professor Owen and Mr. Tomes have both figured a tooth of the hippopotamus that has been fractured near the middle, and been re-united; and the latter in his works has figured more than a single instance of a human tooth that has been so repaired.

In my own practice I have met with one or two such instances, and it is the study of these, to a very great extent, that has led me deductively to pursue the course of treatment that I wish to lay before the profession for discussion.

Pl. I.



Some years since I removed a permanent under incisor from the mouth of a child, whose father stated that the first tooth had been struck severely by a stone. I have no doubt but that the deciduous organ was driven back with such force upon the growing permanent incisor as to dislocate that portion which had been already developed from its position on the dentinal pulp. The result was, that the crown of the tooth was placed at a different angle with the axis of the fang (Plate 1).

A microscopical examination of the structure of this tooth shows that a perfect rupture of the tubes of the dentine took place at A, B, C; the line separating the tissue developed anteriorly from that which was developed posteriorly, to the injury of the crown with the pulp of the tooth, excepting at the extreme lateral limits of the previously developed portion. D D, abnormal cementum; E E E E, enamel; F, Nasmyth's membrane entangled within the dentine; G, concavity worn by mastication; H, normal cementum on the root; K, tooth natural size.

The newer structure is separated from the older by a line of homogeneous dentine; and it is interesting to observe that the tubuli of the former have recommenced their development, not as fractured portions of the older tubuli, but as distinct and independent structures, most of which anastomose with others in the same tissue. At the extreme lateral limit of the crown, the dentinal tubes, instead of being fractured, are contorted to a great

extent, but still continue to retain their connection with the tubuli of the original structure. From this point the development more or less closely approximates the normal character.

Some time after, a second tooth, evidently the result of like conditions with the preceding, came into my possession. Of this I made also a microscopical examination of the structure (Plate 2). In this case the appearances were most dissimilar from the last.

The crown of the tooth was dislocated from its axis to an obtuse angle with the root. The limit of the dentine that was developed previously to the accident was defined by a distinct demarcation traversing the structure in a line sub-parallel with the external contour of the crown of the tooth. From the period of the accident the tissue appears entirely to have changed its character. Instead of a recommencement of tubular dentine, as in the previous case, a large amount of areolar or nodulated structure has suddenly made its appearance, and that dentine of a tubular character which is present is developed from three or four distinct centres, as if the progress of development was spasmodically carried on, until ultimately the normal structure recovered its character.

We have here before us two instances of a reparation of structure after an injury during the progress of development,—the first after a short period, during which it developed homogeneous dentine, having recommenced upon the normal

plan, and with certain defects completed the development of the tooth.

In the second instance we find a complete change of structure, and we have a right to assume that it is derived from an equal amount of change in the state of the pulp previously to the development of the tissue. It is desirable that we should, if possible, obtain a knowledge of the condition of the pulp at the period of the new development, since it is quite evident that they could not be alike in the two instances.

Some time since I received, through the kindness of a friend, a portion of the tusk of an elephant in which an iron bullet had been lodged. The shot, to have been so imbedded, must have entered the pulp of the tusk anterior to its conversion into dentine. In doing this, it carried with it into the pulp also a fragment of the structure that had already been developed into dentine. A microscopic examination of the dentine at this point displays the fragment of normal dentine lodged in a mass of corpuscular ivory (Plate 3). Now, as we cannot but assume that the shot which carried the small splinter of dentine into the pulp must have set up a very considerable amount of local irritation, we must infer that the change in the character of the structure was the result of local excitement.

Upon returning to a comparison of the altered and dissimilar conditions in the two cases of human teeth above cited, I think we may legitimately

infer that the one in which the nodulated dentine is developed is that in which local irritation was the greater, since its character is most pronounced in its departure from the normal structure.

It must be noticed that the previous instances are examples taken from teeth in the full activity of growth, acting under the influence of extraneous or accidental circumstances. The instances to which I now desire to draw attention are those in which a production of tissue takes place resulting from disease.

The first instance to which I allude is that in which the structure, to which Mr. Tomes has given the very appropriate name of secondary dentine, exhibits itself in two distinct forms (Plate 4). One is at the very apex of the pulp cavity, and differs from primary dentine scarcely in anything except the line (Plate 4, *a*) of demarcation between the old and the new structures, which is caused by a deflection in the tubuli themselves. Lower, in the pulp cavity, the second form is seen (Plate 4, *b*); it is continuous with that which I have just mentioned, and forms part of one of the walls of the pulp chamber. This portion of the secondary dentine is distinguishable from the primary by the contorted character of the tubuli, as well as by a line of corpuscular appearance existing at the point of union between the old and the new structures. The change of appearance is caused chiefly by a contortion of the tubuli produced by two or more tubuli uniting to form one.

b

That this secondary structure has been induced through the stimulus of disease is demonstrable from the circumstance that the limits of the new tissue coincide with the limits of the decay,—the one extending on the internal surface to the base of those tubuli which have their external extremities implicated in the disease ; and so dependent is the secondary structure upon this stimulus, that the former gradually decreases in quantity as it corresponds with the limit of the latter.

The lesson that this specimen teaches us is, I think, obvious. The tooth was attacked by caries upon the summit, which gradually progressed down the side of the tooth.

At the earliest stage of the disease the excitement that was produced in the pulp stimulated the latent developing power of the dental organ into renewed activity. The stimulus that first induced the new structure must have differed in degree but little from that which existed in the pulp when the primary structure was normally produced. Later, when the disease had penetrated deeper into the tooth, a more active excitement was induced, and the result was a growth of secondary dentine, differing in a greater degree from that of the normal or primary structure. The disease still progressed until an inflammatory action was set up in the pulp itself, and the tooth was necessarily removed.

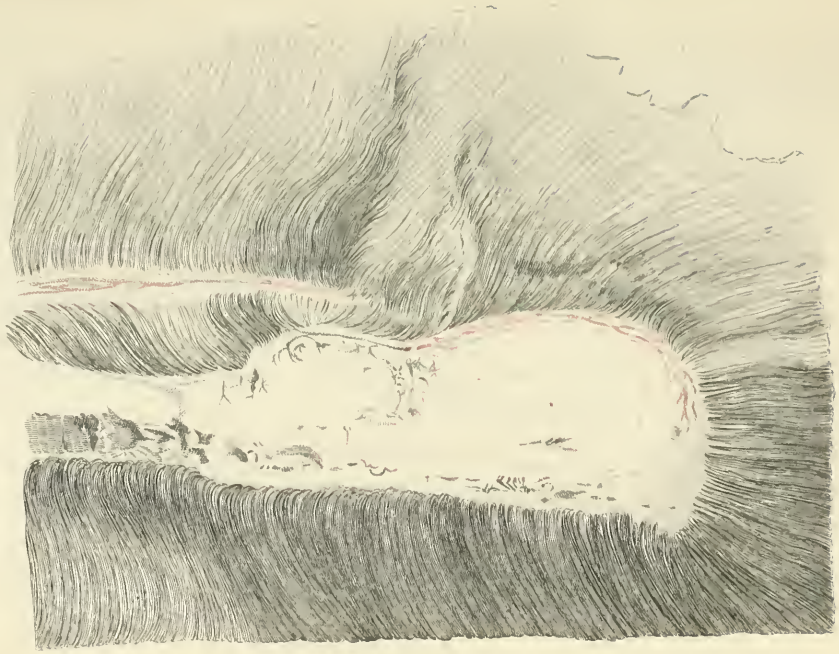
The next case to which I shall allude is that of a tooth extracted from an old female (Plate 5). It

was the first tooth she had lost, and, as far as I could observe, was the only one that was decayed. The patient was seventy-four or seventy-five years of age. The tooth on this account appeared to me to be suggestive of information, and, after having extracted it, I made a section from it for the microscope. The pulp cavity in this case was almost filled with secondary dentine of homogeneous or structureless appearance. The new structure was united to the old upon one side, but the remains of the dentinal pulp existed upon the other. The pulp was reduced to a very small thread, but which, upon being inflamed, induced the severe amount of pain that caused the tooth to be extracted.

I think that the history of this tooth may be read in the structure. A long and slow decay of the dentine induced an equally continuous development of secondary structure. The progress of the disease being slightly more rapid than that of the repair, superinduced at length an inflammatory action in the remaining portion of the unossified pulp, and the consequent loss of the tooth.

It is well known that sound and healthy teeth which have been worn by mastication to a great extent have the dentinal pulp converted into secondary dentine.

The new tissue is generally distinguishable from the old by the lessened number of the dentinal



tubuli. In all other respects it forms part of the tooth, perfect in its attachment and solid in its structure.

An examination of the different kinds of structure in the newly-developed or repairing dentine, will, I think, legitimately lead us to conclusions that have, I believe, a practical value in the curative treatment of the organ.

If we examine those instances wherein the greatest amount of repair has occurred, we find that they exist in those teeth in which the primary tissue is still in progress of development, and not only so, but at a period in which the entrance into the pulp cavity is as wide as the entire structure of the tooth. At this period the organ possesses an analogous condition to those teeth that possess the power of perpetual growth. Hence we perceive that the human tooth at this stage possesses similar powers of repair with the tusk of the elephant and the hippopotamus.

But the growth of the tooth of man, unlike the tusk of these animals, has a limit to its development. When the tooth has reached to a certain height above the gum, its power of growth has become exhausted, and the walls of the internal cavity gradually encroach upon the dentinal pulp. This takes place more rapidly upon the fangs than within the crown of the tooth. The consequence is, that the dentinal pulp of a tooth in its fully developed condition consists of a bulb-like papilla,

united with the general system by one or more thread-like processes.

When the internal growth of the dentine has proceeded to a certain extent, development appears to be arrested, or, at least, to progress so slowly as to be inappreciable.

I have said that development is arrested; it would be more correct, perhaps, to have said suspended, inasmuch as we perceive that it retains the capability to produce dentine whenever a sufficient stimulus to excite the latent force is brought to act upon the organ.

Observation of the structure that is developed through an abnormal excitement shows us that the secondary dentine not only differs from the primary, but that itself varies much in character.

I think we may assume with confidence that the variation in the appearance of the secondary dentine must be due to a variation in the degree or amount of excitement that is given to the dentinal organ. If so, then it is legitimate to infer that the secondary structure, which assimilates most in appearance and condition to the primary, has been developed under conditions most resembling the normal state of the dentinal organ during the development of the primary structure; and also that the amount of the abnormal stimulus that is given to the inert organ is represented in the secondary structure by a greater or less departure in its appearance from the character of the primary dentine.

If we examine the secondary dentine in teeth that have been worn down by mastication, we find that the structure is compact and in perfect continuity with the primary dentine, from which, in appearance, it differs but little, except in the less conspicuous character of the tubuli. I think, therefore, that we may take for granted that the amount of stimulus that is given to the pulp by the friction of mastication upon the exposed surface of dentine is just the degree that is necessary to induce in it a renewal of its almost exhausted powers of development.

Any higher degree of excitement will be spasmodic or irregular in its action, developing dentine of a nodular character, which, according to the amount of stimulus, will be more or less perfectly united together, forming an imperfect structure, or exist in detached nodules. Such development can scarcely fall within the category of being a curative repair.

If we turn our attention to the state of the dentinal organ at this stage of its existence, we find that it is fed by arteries that pass through very minute osseous canals. It therefore stands to reason that such an organ cannot receive any amount of stimulus beyond that of the mildest condition without producing congestion within the pulp cavity; for the power of free circulation from so large and vascular an organ as the dentinal bulb, through the fangs, must be very limited,

and liable to interference,—a circumstance that must considerably impede the repairing capability of the organ.

This idea leads directly to the inference that the dentinal pulp, whenever it has been stimulated to a degree that amounts to inflammation, is incapable of producing secondary dentine of curative importance; and that the treatment of the pulp with this intent almost invariably leads to disappointment.

I am aware that, several years since, Dr. Harris stated that it was capable to induce the production of secondary dentine not only within the pulp chamber, but also external to it, the repair taking place in a cavity left in the plug, which became filled by the new structure at the base of the plug. I am not aware that any other operator ever met with the like, and I believe that Dr. Harris himself latterly discredited his previously expressed statement.

It has been the endeavour of many practitioners to induce a repair of the dental tissue by exciting the dentinal pulp to produce secondary dentine, and, although in some instances favourable hopes of success have been attained, my own experience, which has long and patiently been tried, has led to disappointment.

That secondary dentine is capable of being induced as a valuable repairing structure anterior to an inflammatory action having been set up, I feel

quite certain, and hope, at no very distant date, to have the pleasure of laying before this Society some satisfactory illustrations on this important circumstance. But I as strongly believe, that an inflammatory action once having been induced, the prospect of its terminating in resolution is a practical impossibility, and leads to the inference that the extirpation of the organ is the proper treatment to pursue.

Treatment.—Having arrived at the conclusion that the removal of the dentinal organ from the pulp cavity is the correct treatment, the next step is the consideration of the means by which it is to be removed.

The extirpation of the pulp may be either by direct instrumental manipulation, or through the agency of some potent escharotic.

The former is but occasionally practicable, but when it is capable of being done adroitly, it is certainly by far the most satisfactory mode of practice.

The latter, in consequence of its numerical importance, is that which must receive the greatest consideration in an inquiry upon this subject.

In looking for a chemical agent which will disorganize the pulp, the requirements are speedy and painless action. The caustics that have been used for the purpose have chiefly been nitrate of silver, nitric acid, potassa fusa, chloride of zinc, and arsenious acid.

The first four have fallen into considerably lessened use from their apparently uncertain action, while the last has been growing into disfavour from the great amount of pain that frequently accompanies its action, and the large percentage of cases that are ultimately rendered unsucessful by an inflammation having been superinduced in the peridental membrane, which results either in an alveolar abscess that compels the extraction of the tooth, or in a chronic gumboil, the latter being probably the more frequent.

To so great an extent has this been the case, that Mr. T. Rogers, in his paper on Caustics in the second report of this Society, p. 117, while preferring it to all others, says that we must "regard arsenic as occupying its present position in our list of remedies only till a safer preparation shall be discovered."

The separation between success and failure often is only the result of minute differences. The active nature of arsenic as a mineral poison has had its influence upon its use when applied in the mouth. The aim of the operator has been to obtain a minimum amount of the material that is capable of destroying the vitality of the dentinal pulp.

In Mr. Tomes' "Manual of Dental Surgery," the quantity that is recommended is stated to be the twenty-fifth part of a grain, and this I believe is a larger dose than Dr. Chappin Harris and

other writers have found necessary. After its application from twelve to thirty-six hours, Mr. Tomes says "that one patient will tell you that the application produced no pain; another that the toothache was most severe, and lasted from ten to twelve hours; while a third will describe the pain as moderate in degree, and of a very bearable kind;" and "if the result has been favourable, the sensitiveness, before so great, will have entirely passed away."

The difference that exists between the ordinary mode of practice and that which I wish to lay before this Society, lies in the trifling alteration of exchanging the minimum amount of arsenious acid that is capable of producing the desired effect, for the maximum quantity that can be safely employed; the result of which alteration enables me with confidence to remove all doubt in the success of the operation, and convert it as a permanent rule, which the exceptions tend to corroborate, to an almost painless one. In the last 200 cases that I have treated, I have not had above a dozen that complained of pain; not a single case of gumboil has followed the operation; two or three only in which I have had to remove the plug from an irritation of the gum, each of which I had reason to attribute to a defect in the plug; and not a single case has resulted in the loss of the tooth.

One great feature in the action of arsenic has, I think, by the advocates of a minimum dose, been

overlooked,—that it is capable of being absorbed into the system when applied in small quantities, but that in larger quantities it tends to a contraction of the muscular fibre, and acts as a powerful escharotic.

I remarked, a few lines back, that the exception corroborated the success of the practice. It is to these that I shall chiefly draw attention, as from failures we learn what to avoid.

The causes that induce failure appear chiefly to arise from difficulties in manipulation, either from the position of the tooth in the mouth, the nervousness of the patient, or, as in the following case, the great flow of blood into the cavity.

I allude to this last case first because it was so directly under my own observation throughout, being a female servant in my house.

The tooth was a first under molar; it had been aching severely for several days. While preparing the cavity, previously to inserting the arsenious plug, I wounded the gum, which bled copiously, it being of a somewhat fungous character. After waiting and using cold water, I introduced the arsenic, the blood still pouring out abundantly. The tooth pained all the night; and upon examining it the next morning, I found the pulp in the tooth apparently unacted upon. The bleeding had now ceased; but the pain was so severe, that the patient desired that the tooth should be removed. I inserted again a fresh arsenious plug,

and the pain within a few minutes entirely disappeared; and four and twenty hours after I permanently plugged the tooth.

The second case to which I allude was a lady, so excitably nervous that I was glad to get the arsenious plug in the best way I could between two closely compressed molar teeth. The tooth was described as having pained severely for the whole night. It was successful, and permanently filled the next morning.

A third case was one that was perfectly successful as an operation; but some two or three months after, the patient complained of pain in biting on the tooth. To an inquiry, he informed me that he felt something hard, and felt a jar, from which time the tooth got uneasy. Examination showed to me that a portion of the enamel had broken, apparently arising from a defect at that point in the plug; to which circumstance I attribute the cause of the pain. The removal of the stopping brought immediate relief.

Another case has a parallel history; it was in the mouth of an officer of engineers, of delicate health. I removed the plug, introduced tannin into the cavity, and refilled with temporary stopping. The pain subsided, and a short time after, the tooth was refilled permanently.

The last case to which I shall allude is one of much interest.

A gentleman who had been wearing artificial

teeth for some time drew my attention to a small area of the palatal surface of the crown of an otherwise healthy first upper molar. The dentine had softened to some extent, so I thought it would be better to plug the spot; to do which I had to cut beyond the present depth of the decay. The dentine was very sensitive, and nothing could be done until the sensitiveness had been removed. The application of the arsenic was a matter of some difficulty; but this was partially overcome by the assistance of the clasp attached to the plate that passed round the tooth. The next morning the dentine was perfectly insensible to the touch, and the tooth was securely plugged.

About a fortnight after, the patient complained of sensitiveness in the tooth, from the application of cold or hot water. This daily increased, and ultimately became severe.

Attributing this circumstance to have resulted from the absorption of arsenious acid by the dentinal tubuli, I assumed that an inflammatory action of the dentinal pulp had been induced; and nothing was left but to destroy that organ altogether. For this purpose, I drifted through the decayed cavity into the dental chamber, for the purpose of applying the arsenic. It was, however, with some astonishment that I found, upon opening into the pulp cavity, that the dentinal organ was already destroyed. No doubt

but that the chamber was filled with suppurative matter; for the pain in the tooth immediately permanently subsided upon the penetration of the instrument into the pulp cavity.

To enumerate cases of this kind would be tedious. I will therefore close my remarks upon the destruction of the dentinal pulp, by detailing the *modus operandi* that I pursue.

It is desirable to have, in all operations upon an organ so sensitive as the pulp of a tooth, a distinct view of the bottom of the cavity in which you are manipulating; for I believe that the first thing that is to be done, especially when the patient is labouring under pain, is to remove from the surface of the pulp as large a portion of dentine as is practicable. I have frequently known this alone to give relief to severe pain, by permitting the dentinal pulp the power of expansion when in a highly congested state.

In order to expose the pulp with as little pain as possible, it is desirable to cut away the dentine around, rather than over, the pulp cavity. For this purpose I have found hollow drills to stand me in good service, in cavities where they can be brought to bear. When the drill, or chisel, has cut sufficiently deep, the plate of dentine can readily be removed, and the pulp liberally exposed to view. If the opening be large, the organ can, with a firm and steady hand, be quickly removed. But the fear of the patient, and the dread of

failure on the part of the operator, often militate against the success of the operation.

The pulp being well exposed, I take a pledget of cotton, about one-third the size of the cavity. I dip this into creosote; and having placed upon a glass slab, from one-quarter to one-half of arsenious acid, more or less, according to the size of the tooth to be operated upon, I mix it with the creosote, and place it into the cavity in direct contact with the pulp. It is then covered over with a temporary plug, and hermetically sealed in, without being tightly pressed upon the pulp. I cannot lay too great a stress upon this latter portion of the operation, since, in the first place, I think that the diminished amount of pain much depends upon it, and the risk of the arsenic passing into the mouth precluded.

The action of the arsenious acid so employed is very rapid. In two or three instances I have been able to permanently plug the tooth in about four hours after its application; but my general practice, which is much dictated by convenience, is to complete the filling four and twenty hours after. To accomplish this, I have not failed in a single instance in the last nine months.

I would here state, in allusion to the removal of the dead pulp after its destruction, that, however desirable it may be, it is often impracticable; and my experience is by no means unfavourable to its remaining in the tooth. That it will discolour the

tooth is a misfortune, where it occurs in the front of the mouth; but most certainly my experience leads me to the conclusion, that where arsenic is used in large doses it is never absorbed into the structure of the tooth; and in the few cases wherein pain has occurred I have attributed it to a fragment of the pulp not having been so entirely cauterized as to exclude it from decomposition. This, if allowed to remain, would induce an inflammatory action in the peridental membrane, and therefore should be removed immediately.

If I have reason to suspect too large an application of arsenic to the tooth, I insert for a day or two, beneath a temporary plug, a quantity of hydrated sesqui-oxide of iron; but my common practice is, on the removal of the arsenious plugs, to introduce the permanent plug at once.

The satisfactory results that I have obtained, together with the confidence in the practice that has gradually been extending in the minds of my patients, has been such as to induce me, without loss of time, to communicate it to the members of this Society.

GENERAL MONTHLY MEETING.

Monday, May 4, 1863.

SAMUEL CARTWRIGHT, Esq., President, in the Chair.

The following Gentleman was duly elected a Member of the Society :—

Mr. Charles West, 9, London Terrace, Hackney Road.

The Members of the late College of Dentists were elected Members, and the name of the Society changed to the Odontological Society of Great Britain, a full account of which will be found in the minutes of the Society.

The following Donations were made to the Library and Museum :—

By Mr. W. A. N. Cattlin.—A series of wax models showing the difference in size of the human antrum.

By Mr. Balkwell and Mr. W. A. N. Cattlin.—Models of cases of Epulis.

By Mr. J. J. Keene.—The following formula for a stopping, with specimens. R oxide of zinc, 8 parts; oxide of cadmium, 1 part; silica, pulverized and sifted, 1 part. Place in a stoppered bottle oxide of zinc; pour on muriatic acid of commerce, taking care that the oxide is in excess; let this stand for a few days—the longer the better; decant off the clear liquid, which use with the above. Tint the stopping with ochre, according to the shade required.

Mr. Balkwell brought before the notice of the Society a case of *Epulis*.

About four years ago a young lady, now nineteen, had the two upper central and the left lateral incisors pivoted with mineral teeth. The crowns, which were originally much honeycombed, had become carious, and were excised. The right lateral had been previously extracted. The pivoted

teeth became a source of frequent irritation; but at Christmas last, when I saw her, there was no gumboil. In the middle of February she received a violent blow, which knocked out an artificial tooth, loosened the stump, and caused the gum to swell. Within three weeks the artificial tooth was replaced, and fastened in with the new "osteoplastic" stopping; the fang had somewhat protruded, which necessitated the bending of the pin to bring the crown in line with the others again. The swelling of the gum increasing, leeches were applied. About a fortnight afterwards, the swelling continuing, the family medical man who was in attendance was requested to examine the gum, and he, suspecting abscess, lanced it crucially, but no matter escaped.

A lotion of iodide of potassium was then ordered. In the course of the week he saw it again, and advised the extraction of the pivoted fangs.

The dentist who did so recommended the excision of the growth; but on cutting, it bled so freely that he desisted, after having removed part of the inferior surface, and attempted to burn it back with nitrate of silver. Having occasion to leave the town for a few days, he gave directions for the continued use of the caustic, which was attended to; but the swelling increased rapidly and became harder, the upper lip projecting about an inch beyond the lower.

On the 8th of April she came up to town to consult Mr. Paget, who pronounced it a decided case of epulis, and advised immediate removal. This model was taken by me at that time for our museum, should the Society think it worth a place there.

She returned home on the 10th of April, and the operation was performed on the 14th under chloroform.

The left canine was first extracted, then the lip separated from the tumour with a scalpel, and the epulis freed by two cuts of Liston's curved forceps, removing the entire walls of the alveoli from the right canine to the left anterior bicuspis. She was got into bed, and a pledget of lint kept pressed in the cavity to prevent bleeding; this, however, was not much. There was some swelling and feverishness, which gradually decreased, and the wound is healing up rapidly.

Likewise another case which came under Mr. CATTLIN's care at the Islington Dispensary:—

Some time ago, he removed a very small epulis by excision and nitric acid from the anterior part of the gum, opposite the first right lower bicuspid tooth. The growth was so small that he did not think it necessary to cut out the alveolus.

Two years afterwards the patient returned

with the growth on the opposite side of the lower jaw. Mr. Cattlin then recommended the removal of the teeth and their alveoli with the epulis, as the only effectual way of preventing a return of the disease. The patient declined to have the operation performed at that time, and did not again appear at the dispensary. It was subsequently found that she had given a wrong address.

Mr. Ibbetson introduced to the notice of the Society a case of retarded eruption of the permanent teeth, in which all the temporary teeth of the superior maxilla, except the posterior molars, were knocked out at the age of two years; and he likewise presented a model of the case which was taken at twelve years of age, which had the appearance of a well-developed alveolar arch, but none of the permanent teeth had been erupted, with the exception of the first permanent molars. The accident was confined to the upper jaw, none of the temporary teeth in the lower jaw having been involved, and there the eruption of the second dentition had taken place at the normal period.

Mr. Coleman brought before the Society a case which came under his care at the Metropolitan Free Hospital within the last three months:—

A patient, aged about fifty, having a fistulous opening. The poor fellow was in a miserable state from the continual flow of saliva down the right side of his neck—the side of the opening. He had had the opening communicating with the mouth for about two years. Several years previous to this he had alveolar abcess, arising from the stump of a second bicuspid, on the right side of the lower jaw. This left a fistulous communication with the fang, continually discharging; and when the fang came out, which it did of itself, the communication with the

mouth, through the alveolus of the stump, was established. The canal leading into the mouth was nearly one inch and a half in length—two-thirds being fleshy, the rest in the bone. In order to relieve the patient, he adopted the following operation. He took a fine double-edged bistoury, and very freely removed the cuticular parietes of the fleshy portion of the canal on all sides, except at the posterior—for here the facial artery ran almost into the cicatrix. Having done this, he made subcutaneous incisions, so as to relieve the skin at the external orifice from all tension, and allow the edges of the wound to come together, which they did; when he secured them by silver sutures. The wound healed readily by first intention.

GENERAL MONTHLY MEETING.

Monday, June 1, 1863.

SAMUEL CARTWRIGHT, Esq., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Mr. J. B. Bell, 30, Margaret Street, Cavendish Square.
Mr. R. Forward, 3, King's Terrace, Southsea.
Mr. H. R. Rowe, 60, Fishergate, Preston.
Mr. J. Steele, 63, High Street, Croydon.
Mr. G. Walker, 19, Cumberland Street, Pimlico.

The following Gentleman was proposed for the Membership of the Society:—

Mr. R. Ramsay.

The following Donation was made to the Museum:—

By Mr. Normansell.—The model of an upper jaw, with a supernumerary tooth in front of the posterior molar.

Description of a group of supernumerary teeth, removed from the front part of the mouth anterior to the canine teeth. By John Tomes, F.R.S., &c.

On a previous occasion I brought before the Society a collection of minute supernumerary teeth taken from a cavity in the alveolar portion of the upper jaw by Mr. Tellander. I have now to place before the meeting a case still more extraordinary, but not in all respects dissimilar.

An old friend and fellow student, Mr. Mathias,

soon after entering the medical service in India, was posted up country at a civil station, where few Europeans showed themselves. He there became famous as an operator among the natives. On one occasion a Hindoo, aged twenty-five, presented himself in the following condition. A large foul tumour occupied the front part of the mouth, pressing the upper lip against the nose, and acting the part of a gag by preventing the closure of the mouth. The surface of the tumour was eroded by ulcers, from which an offensive discharge was emitted. The general appearance of the diseased part and the constitutional condition of the patient suggested malignant disease as the character of the malady. The man was taken into the hospital, and the native dresser was directed to apply charcoal poultices, in order to get the diseased part into a cleaner, if not a more healthy, condition. After the lapse of a few days, Mr. Mathias examined the case, and with a probe detected beneath the surface of the tumour a hard body which, from its density, he suspected to be a tooth. This he removed, and found the suspected tooth to be a series of ill-formed teeth united. The examination was repeated, and a second mass was removed, and then another, and another, to the number of fifteen. (Fig. 54.) The soft parts rapidly assumed a healthy condition; all deformity disappeared, and the mouth showed scarcely any other peculiarity than the absence of the central

and lateral incisors. The canine teeth occupied the usual position.

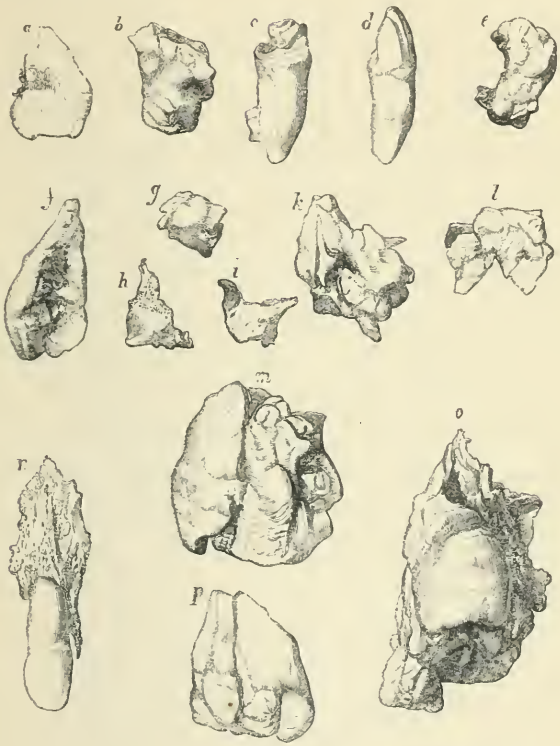


FIG. 54.

Such is Mr. Mathias' description of the case. He did not, however, limit his attention to the treatment of the patient; but remembering the interest an old friend took in all that related to the dental organs, carefully preserved the teeth he removed, and brought them to me, on his arrival in this country.

An examination of the figures will give a more accurate idea of the conglomerate masses of imperfectly-formed teeth than a verbal description would convey. In the two larger masses *m* and *o*, will be seen the crowns of ill-formed central incisors, the presence of which would sanction the supposition that these occupied a central position in the tumour, and that the other masses were arranged around them. But it is impossible to reconstruct the tumour by building up the parts preserved in the positions they occupied. There is no clue to their respective places; moreover, there are fractured surfaces to which no corresponding parts are preserved. Hence it may be concluded that we do not possess all the hard parts which entered into the formation of the tumour,—a fact noticed by Mr. Mathias, when he brought me the preparation.

In *n* and *d* we have tolerably well-formed teeth, and a portion of alveolus is attached to *n;* but the position they occupied when in the mouth cannot be determined. The interest of the preparation would be increased, could we place all the parts in their relative position; but the re-arrangement is of secondary importance. The true value of the case lies in the demonstration of the fact that large masses of dental tissues, more or less taking the form of teeth, may be developed in the region of the incisor teeth of the upper jaw.

Mr. Coleman, the Secretary, read the following:—

The Prize Essay on the Pathology of Dental Caries.

By Mr. W. K. Bridgman.

INTRODUCTION.

The part played by Electricity in the organic world has long been a perplexing puzzle to the philosopher as well as to the physiologist.

Its action in the animal system is looked upon as something distinct from that force which is usually denominated "vital," although it is admitted there is much that may be considered as identical with it,—so much so, indeed, that it becomes a difficult question to decide whether the one or the other prevails, or to find a line of demarcation between them. In addition to this fact, there have been so many purely electrical phenomena at different times developed from the living subject as to have given rise to various hypothetical arrangements of batteries supposed to exist in the human frame; and yet, strange to say, the one condition more than any other intimately associated with it has been the least attended to. Chemical action and electricity are known to be so far inseparable as to render it impossible that the one shall be produced without at the same time the other becoming manifest; and it has been said by Professor Faraday, that "chemical action is often a more delicate test of

electricity than the galvanometer; yet, with the knowledge of electricity being thus developed in animal life, it is most surprising that hitherto its electro-chemical effects in the living organism should have remained so little regarded.

It has been demonstrated also by the same Professor, that "*electricity, whatever may be its source, is identical in its nature;*" and it was supposed by Dr. Wilson Philip "that the nerves which excite the muscles and effect the chemical changes of the vital functions, operate by the electric power supplied by the brain and spinal marrow, in its effects modified by the vital powers of the living animal; because he found, that while the vital powers remain, all these functions can be as well performed by voltaic electricity after the removal of the nervous influence as by that influence itself." (*Note by Faraday.**)

It was announced by Professor Brande, that "when liquid albumen is made part of the voltaic circuit, it presents appearances dependent upon the power used, which, when considerable, excites so much heat as to coagulate it; but with a feeble power and the poles sufficiently distant, coagulation ensues most plentifully at the negative platinum wire; a coagulum also forms at the positive wire, *where acid is sparingly evolved.*" (*Manual*, p. 1138.) The preceding discovery having been made prior to the days of "electricity," its signi-

* Phil. Transactions.

ficance remained unheeded; but the manner in which the metals are acted upon, in being reproduced from their solution into the metallic state, and in any desired form, has become a fact so well known at this time, under the above title, or "Electro-Metallurgy," as to render it a matter of less surprise that *organic* material should be dealt with in a somewhat similar way. In experimenting with a viscous solution for a specific object, it was discovered that albumen from the egg, serum from the blood, milk, and other organic substances, were not merely "coagulated," but were *disposed in a definite form and arrangement of parts, possessing characteristic peculiarities,* in some instances resembling very closely some of those substances hitherto supposed to belong to that class usually regarded as "vital" productions.

The earthy salts, likewise, are influenced in a peculiar manner. Not only are the salts of lime taken out of their original basis of bone or dentine and transferred to other localities and reproduced in the same or a different form of crystallization, but the acid may be separated from its base, leaving both the acid and the base either free and uncombined, or suffering both to form other combinations. "Such," says Sir Humphry Davy, "are the decomposing powers of electricity that not even insoluble compounds are capable of resisting their energy; for even glass, sulphate of barytes, fluor spar, &c., when moistened and

placed in contact with electrified surfaces from the voltaic apparatus, are slowly acted upon, and the alkaline, earthy, or acid matter carried to the poles in the common order."

"The chemical action of voltaic electricity," says Faraday, "is characteristic of that agent, but not more characteristic than are the *laws* under which the bodies evolved by decomposition arrange themselves at the poles." Thus, whenever *acid* appears, it is invariably at the electro-*positive* pole, and may be taken as conclusive evidence of that condition, while the *alkaline* state evidences the electro-*negative*. Hence the external layers of the skin, the mucous membrane of the mouth, &c., and the dentine of the tooth, are unquestionably in an electro-positive state, and consequently are liable to the development of acidity. The source of this acidity may be either the serum of the blood or the saliva—the latter of which is so easily decomposed that I have obtained enough electricity of sufficient intensity from a battery contained in a small silver thimble, with a few drops of diluted sulphuric acid, to redden litmus-paper in a few seconds when moistened with saliva.

Now, although we have occasionally an acid condition developed in certain parts, and occurring at one time more than another, these, except perhaps in such cases as the gastric juice of the stomach, &c., may be considered as somewhat

abnormal; the normal action being that in which the change of elements goes on so slowly and regularly that the elements of each acid or basis may be appropriated as fast as they are liberated, and so taken up as not to be allowed sufficient time to manifest either acid or alkaline qualities.

Under these circumstances it becomes extremely easy to explain all the phenomena of *dental caries* as being produced by *electro-chemical* action; and as this *abnormal* action can be shown to be only part and parcel of its *normal* action as developed in other parts of the system, and can be demonstrated *out of the system* from the same materials by these same means, there are strong grounds for believing in their identity of action.

There are cogent reasons also for assuming that if any great advance is to be made upon our present stock of physiological and pathological knowledge, it will have to be sought for in this direction; and when there shall be found in one individual an Owen and a Faraday, or a Huxley and a Grove, combining the profound knowledge of the physiologist with the consummate skill and tact of the electrician, *organic* matter may stand a chance of being taken to pieces and tortured to confession, with as much pertinacity as that which has already compelled inorganic matter to yield up the history of its own existence.

PATHOLOGY OF DENTAL CARIES.

1. The pathology of a subject involved in so much obscurity as the one now under consideration, occurring as it does in a substance respecting which it has never yet been definitively settled whether it has to be regarded as a vital body *possessed of vitality*, or as merely a vital product amenable only to the ordinary physical laws of inanimate nature, can only be adequately treated by first determining to which of the two conditions it has the more legitimate claim.

2. Until quite recently, the dentinal portion of the tooth has been regarded as part of the vitalized substance of the organ. Professor Bell observes: "That the teeth possess vitality; that they are connected by their organization with the general system, having nerves, blood-vessels, and absorbents, and are analogous in this respect to other bones, is a truth so strongly attested by all the phenomena they present, whether in a healthy or a diseased state, that it is difficult to imagine upon what grounds it can have been controverted, or even doubted, by any one whose opinions are deduced from observation or experiment. The question is not whether in the internal cavity of a tooth nerves and blood-vessels exist, for this is too obvious to require proof; but whether these essential components of animal organization do or do not enter into the composition of the tooth itself."

3. The existence of the dentinal tubes and the recent discovery of the dentinal occupants of the tubes (the soft fibrils of Tomes), and these being in connection with or extensions of the pulp into the substance of the dentine, might seem to give additional if not conclusive weight to the above argument; but it has been shown by Messrs. Tomes and De Morgan* that dentine is *not* organized "like other bones;" *there is no constantly recurring action* of absorption and reproduction going on in the dentine of the tooth, as has been demonstrated by these gentlemen to occur in *ordinary bone*. Besides this, we must take care no longer to suffer ourselves to be misled by mixing up the *physical* with the *vital*, so as to confound the purely *vital* condition of the pulp and its fibrils with the merely physical character of the dentine—a substance which forms only an exterior coating of a compound, though strictly physical nature, *provided solely for a mechanical purpose*, and bearing the same relation to the vital pulp of the tooth that the shell does to the egg or the rind to the orange.

4. The only apparent action of vitality that can be traced in the tooth is in furnishing material for the subsequent depositing of new matter; but this is strictly a physical result derived from an action of vitality in the pulp, which leads to its shielding itself with a further deposit of a non-vitalized protective covering.

* Phil. Transactions.

5. The pulp being endowed with feeling, is apparently capable of receiving impressions from abroad; and this power of being irritated by external agents excites it to the exercise of its function in consolidating a zone of the tubes by means of its fibrils, so as to insulate itself from the irritant. This action clearly indicates the existence of some kind of condition rendering the proceeding desirable. To suppose it to arise from a "consciousness," is to ascribe to the pulp a degree of intelligence by no means in accordance with known and acknowledged facts. To assert that the want is telegraphed to the brain and a reply sent back from the depôt at "head-quarters," is a mere hypothetical assumption based upon no traceable knowledge of facts.

6. But it is not needful to hypothesize, since it can be demonstrated by actual experiment that the production, electro-voltaically, of new matter under such circumstances is one of the inevitable consequences of the condition of the parts when and where it is formed, and that it is only the fulfilment of one of the laws pertaining to the electro-biology of the subject.

7. All physiologists agree in admitting the probable existence of some kind of arrangement in the animal frame answering in its effects to an electrical battery, and we have most unquestionably a portion of such an arrangement constituting the

outward coverings of the system. The peripheral layers, known as the skin, consist of three distinct parts—the outermost, or epidermis, composed of a series of scale-like laminæ, constantly being formed from beneath, while the upper or external ones are simultaneously drying up and being cast off.

8. The next layer immediately beneath the epidermis, the basement membrane, a thin homogeneous, soft stratum of transparent and structureless substance, identical with the material of the epidermis, but wanting the structural arrangement which, in its turn, converts it into the latter.

9. Below the basement membrane lies the network of nerves and blood-vessels in a layer parallel with the outward surface of the cuticle.

10. It is from these blood-vessels, contained in the cutis, or true skin, that the albuminous material is obtained, and is first formed into basement membrane, and then further elaborated into the mucous layer of the cuticle. The liquor sanguinis, flowing through the capillaries in a regular and constant stream, furnishes a continuous supply of fresh material, as portions become abstracted for local use; and thus the whole of the soft structures outward of the blood-vessels are continually changing, through being formed and subsequently discarded.

11. But it may be asked, In what way does all

this constitute it a "galvanic battery?" The answer is, that the condition and arrangement of the several layers are incontestably those of an electro-voltaic series, while the actions performed are essentially those of a voltaic combination.

12. If a plate of zinc, and a plate of copper or silver, be dipped into an electrolyte and made to touch each other, galvanic action ensues. The zinc, or positive pole, develops acidity and is wasted in bulk, while the liquid, or electrolyte, is decomposed, and its elements are carried different ways, one part to the zinc and the other to the copper; or, as is shown in the Appendix, when albuminous matter is acted upon, although the water and various salts it may contain will be decomposed, the albumen itself is arranged in a definite form.

13. It has been asserted by Professor Faraday, that such elements as are most powerfully combined are the easiest to be decomposed; but that substances held together with a very feeble affinity, such as albuminous matter, of which all organized beings principally consist, are extremely difficult of decomposition. In this we see a beautiful provision of Nature, and also a fact which tells most forcibly in favour of the belief that the electrical force developed and maintained by the *vital* arrangement is the agent employed by the all-wise Creator in moulding organic

matter into the various forms and bodies required in carrying out the materialization of the living organism.

14. It has been demonstrated* that albuminous matter is not merely consolidated by the electro-voltaic force, but that it also assumes a kind of organization. The material at each pole possesses a special and distinct character, at the same time that a solid wall of structural substance grows up between them at the point where the two conditions of the force may be supposed to meet, spreading out quite across the vessel, and forming a membranous diaphragm or partition, dividing into two compartments the two portions of the electrolyte in opposite states, corresponding to the condition of the pole immersed in it. In electro-metallurgy the precipitated metal adheres to the negative pole, but with albumen it *recedes* from the pole, thus in nature preventing the negative vessels becoming clogged by a casing of their own depositing.

15. This, however, is not all; the salts of lime contained in the albumen, or added to it, become arranged organically within the substance of this diaphragm, constituting it a membranous matrix, *which corresponds with and occupies the place of the under part of the basement membrane in the skin, and the dentine in the tooth.* We have thus a double result,—first, the production from the

* See Appendix B.

liquid albumen of a solid membranous matrix, and its then becoming tenanted by the salts of lime, converting that which was at first only a piece of tough and elastic "gristle" into a hard and stony mass.

16. In addition to this, we find the consolidated material arising on the *positive* side of the transverse matrix containing unmistakeable proofs of acidity, while the negative side is neutral or alkaline.

17. Reverting now to the conditions and arrangement of the parts comprising the skin, or "Peripheral Battery" of the animal system, it may be stated, that when giving out albuminous material for new growth, the blood is invariably in an alkaline state; and therefore, if the part be in an electrical condition at all—and Sir Humphry Davy came to the conclusion that all bodies in nature were in one or the other of the two electric states—it cannot be positive, and must consequently be *negative*. For the same reason that the alkaline blood-vessels must be negative, the epidermis, or the epithelium, must be positive; and on being tested with blue litmus-paper, it will be found to be less commonly neutral than giving strong proofs of acidity. We have, lastly, the albuminous matter from the blood-vessels, in the formation of the basement membrane, spreading out laterally between the two electrodes, the cutis and the cuticle, in the form of basement

membrane, precisely in the same manner as has been observed to take place artificially.

18. In tracing the correspondence still further, we shall find the several membranes of the skin answering in their actions to the electro-polar condition of an electrolyte, or matter in a state of induction between the two electrodes.*

19. If a piece of metal be suspended in a solution capable of dissolving it, and through which an electric current be made to pass, one portion will be dissolved, while the portion on the opposite side will be added to by a new deposit; and should there be three or four, or more, each one will be affected in a similar manner, the wasting end or side of one being always opposed to the increasing or growing side of the next in succession.

20. In depositing metals, the new deposit forms upon or in contact with the negative plate; but with albumen, as previously stated, the solidified portion recedes from it; so that if the wire from the battery were a hollow tube, furnishing a continuous supply, it would lead to the gradual increase of the solid part forming around it, and

* It has been deemed unnecessary to make any allusion to the great central part of the battery in connection with the brain and other internal organs, as the arrangement and construction of any small portion of it explains the condition of the whole, which is but a repetition on a different scale. It is the *action* and the *electro-chemical effects* that are more particularly required to be brought under notice, for the same description of changes which are produced in one part of the battery takes place in all.

to its being driven outwards and away from the centre by new layers added to its *interior*. Thus the inner side becomes the negative or growing side, while the outer, presenting itself to the positive pole, is the absorbing or acid surface.

21. Referring now to the analogous condition of the skin, the vessels of the cutis may be taken to represent the hollow negative pole giving out its continuous supply of albumen, and the basement membrane that of the consolidated substance immediately resulting from it. This, from its position, will have its *inner side negative and growing*, and consequently its *upper side positive and wasting*. The cuticle above it will also be in a corresponding condition of *increase below and waste above*. It is only in accordance with the preceding facts (19) that the wasting upper surface of the basement membrane should pass to the under or increasing surface of the cuticle; and although, microscopically considered, no two substances can be less alike, yet the chemist is able to recognize the material of the two as identical in composition, while the electrotypist has become perfectly familiar with transformations equally remarkable, occurring under the moulding influence of electricity.

22. We observe in the tooth papilla, when inclosed in its follicle and commencing to change itself into the tooth, that the new matter no longer goes to form basement *membrane*, but pro-

ceeds to *accumulate beneath it*, forming the *membranous matrix of the dentine*, which, so formed, then occupies the place formerly filled by the increasing portion of the basement membrane.

23. The state of the epidermis and of the epithelium being electro-positive and forming part of the peripheral battery, when these substances disappear and are replaced by another form of covering, as epithelium instead of epidermis, or dentine instead of epithelium, each of these must necessarily be in a similar condition. The fact, however, readily admits of demonstration, as will presently be seen by experiment.

24. Dental caries has been defined as "the death and subsequent progressive decomposition of the dentine." But to accept this definition, we shall have to acknowledge a "life" or "vitality" to have previously existed; for there can be no death in that which never possessed life.* It has been demonstrated that dentine can have no claim to vitality in the usual acceptation of the term: not having in itself the power of growth or of performing any other function of vitality, it can therefore be only regarded in the light of a "vital product," having an organized form and liable to the same physical changes to which other forms of organic matter have to succumb.

25. The discoloration of the dentine, which has been supposed to have arisen from its "death,"

* Appendix A.

is shown by the chemist to be only an ordinary form of decay, occurring under certain conditions in an organic substance : it is termed eremacausis, or slow combustion, the peculiar feature being a slow conversion of some of the elements, while the carbon remains as charcoal. The conditions under which it occurs, depending entirely upon adventitious circumstances, are purely *physical.*

26. With regard to the progressive decomposition of decay, it has been proved experimentally that under the positive pole of an electro-voltaic battery *the lime is taken out of dentine,* and the decalcified structure is invariably *more or less acid*—in both these respects corresponding with the main features present in dental caries, and as the electrical condition which could give rise to these effects will be shown to exist, the sequence must be accepted as an inevitable and natural result of such a condition. The production of acidity in carious dentine has been attributed to decaying food: no bulk of food would be able to produce, under any circumstances, one half the amount of acid often found in a small cavity ; and were the production of the acid external, decaying teeth would never be coated with tartar, as will commonly be found to occur (Fig. 1, Plate 1). A strongly acid carious cavity and tartar upon and around the necks of the teeth, together with an acid state of the gums, is a circumstance of frequent occurrence. A com-

W. Bagg. del. et Sculp.

plete illustration of this may be seen in a specimen contained in the museum of the Odontological Society, where, in a tooth largely coated with tartar, the acid fluid running out of the carious cavity has furrowed away the tartar by dissolving it, *immediately below the cavity*, and showing its source to be within it.

27. In a normally balanced electro-vital action the elements appear to separate and re-combine so as to produce results in a neutral state, but which in an abnormal and unbalanced action give rise to the production of free acid, &c.; thus, in the mouth, the gums may be perfectly neutral at times, but powerfully acid at others, and yet the teeth are not acted upon by the acid unless some physical defect exists in their structure or upon their surface. If we look closely into the starting-point of decay, we shall find that a change takes place first in the organic matrix either of the dentine or its enamel, and before the acid stage can be detected, and that often the same corroding action that is seen in the dentine may be shown to have taken place in the enamel previous to its reaching the dentine, as at *a* (Fig. 2, Plate 1); thus showing that both substances are affected in the same way, although in a different degree, owing to the different amount of organic matter of which they respectively consist. If we take the specimen Fig. 3, Plate 1, it will be seen that a corroding effect has begun at the fissure

in the enamel, while a stained spot with a deeply darkened upper surface extends into the dentine.*

28. Referring now to specimen Fig. 4, Plate 1, we have a similar formation existing in a tooth, but in an earlier stage of decay, or rather before any signs of coming decay have made their appearance: taken singly, it tells nothing; but on being subjected to electro-decalcification, new facts have become revealed. The positive or decalcifying pole was made to rest at *p*, while the negative pole was placed at *n*. After a few hours' action, it was found that a portion of *albumen had become consolidated upon the fissure a, spreading to the round spot below it*, thus screening them from the decalcifying action of the battery, and *showing them to be electro-negative, the same as the part n*. Here, then, we have evidence of "local action" and a starting-point for the commencement of the acidifying stage of decay.

29. It is well known that some forms of carbon or charcoal are amongst the most powerfully electro-*negative* bodies in nature, and when the tooth (Fig. 4, Plate 1) was first ground down and placed in the albumen, the *fissure was filled with a black carbonaceous mass*, which subsequently came away in the cleaning. This, then, was a negative

* This staining of the subjacent dentine would seem to be due rather to the having imbibed colouring matter from the decayed portion, than from any change itself has undergone.

point (charcoal) in a positive substance (dentine), and had it been left to its fate in the mouth, the negative point of charcoal, becoming imbued with saliva, would in time have become the developer of acid, and carried the process on to the stage represented in specimen Fig. 3, Plate 1; further still in Fig. 2, Plate 1.

30. Respecting local electro-voltaic action, Professor Grove says, "If a plate of pure zinc be immersed in dilute sulphuric acid, little or no chemical action takes place; but keep in contact with the zinc another metal, say an iron nail, and the zinc is rapidly oxidated and dissolved, hydrogen being evolved from the surface of the iron. The action is most rapid at the points most proximate to the iron; so that, if the nail be laid upon the zinc, both being immersed in the liquid, the iron would seem to eat its way into the zinc. If a few iron filings be placed upon the zinc, the action will be similar, but will begin more slowly and increase as the points of iron are exposed, these latter being protected to a great extent by their being negative and coated with hydrogen. If an infinitesimal quantity of copper be dissolved in the acid, it will be precipitated in a metallic state on the negative points, and make these permanent centres of action. So, if no iron be made to touch the zinc, after a time some want of absolute homogeneity is sure to determine a chemical action; and as any trace of metal existing in the solution

will by this chemical (or rather electrolytic) action be deposited on the negative point, or those least attached, the action will continually increase, and, instead of being uniform, will be in patches around the negative centres. Thus a piece of common zinc of commerce, which contains small portions of iron and tin, will be corroded in pits and holes. With imperfectly conducting bodies the action is similar; at very short distances they conduct, and the action spreads or extends from a point to the surrounding points. The effects all proceed from a want of perfect homogeneity, either original or impressed by some very trifling circumstance, and from the fact, that points of action having once been established, the corrosion is increased by the effects it itself produces and the deposits it forms. A dentist, to cure a carious tooth, scrapes out all the diseased parts, &c." The above letter to the author of the "British Mollusca,"* in explanation of "substances apparently homogeneous" being "corroded in patches or irregular hollows," with reference more especially to the shells of molluscs, affords a most perfect illustration of our present subject.

31. To obtain a practical illustration of the effects resulting from a *negative* point of carbon, a perfectly sound bicuspid was ground down so as to provide a thick section: in the enamel of this, two cuts, one on each side, were made with a fine

* British Conchology, by J. Gwyn Jeffreys, F.R.S.

dividing-file, and one of them filled with carbon made into a paste with saliva, the other remaining as left by the file. The section (Fig. 5, Plate 1) thus prepared was placed in saliva, the positive pole resting at *p*, the negative at *n*, and subjected to about twenty hours' decalcification.

32. It will be seen that the dentine around *p*, which has been acted upon, and which was originally colourless, as also was the saliva, has become *tinged of a yellowish brown* up to the shaded part *a;* and also, that while the notch on the right-hand side has been rendered wider and shallower, the notch containing the carbon, as well as the outer edge of the enamel itself, remains as *sharp as when first cut.* The decalcifying action of the positive pole has thus included the enamel at the top and right-hand side of the section; but the *left*-hand portion, represented by the shaded part in the accompanying figure, *has been rendered negative* by the carbon, and hence *become coated* with a deposit instead. A more decisive proof of the electro-*negative* effect of carbon, as a source of local action, cannot be desired; and, had time permitted, there is not a question but that by a delicately adjusted balance of feeble electrical action continued over a *longer space* of time, all the phenomena of its producing *local* acidity might have been obtained, as has since been done with a metallic plug of tin (paragraph 34). As it is, however, its action is unmistakeable; and if a

piece of damp litmus-paper be pressed upon the surface, all the decalcified portion will be found to be strongly acid, while the shaded or negative portion is still neutral or alkaline.*

33. This local action engendered, it can only be stayed by removing or rendering inactive the negative part or excluding the electrolyte so as to destroy the means of further electro-voltaic decomposition; and it will not fail to be recognized that this is the exact process we invariably resort to in the treatment of dental caries. We know by experience that not only must all the injured part be removed, but we must endeavour to exclude the moisture, to prevent its relapsing into the same condition.

34. These electrical conditions may also serve to throw some light on a circumstance respecting which very little is at present known—that is, why some substances answer better for filling the cavity in a decayed tooth than others. Respect-

* The particular acids traceable in the mouth depend very greatly upon what elements the electrolyte may have held in solution at the time, and to show that substances taken internally are detectable in the fluids of the mouth. A piece of white paper, moistened with saliva from a source where three grains of iodide of potassium were being taken thrice a day, five hours after the last dose, was touched with the platinum wires of the battery, when the iodine was instantaneously manifested by the violet stain of the starch test supplied in the sizing of the paper. The deep yellow stain often seen at the necks of the teeth and in the decay of the fangs, may in the same way be communicated by minute portions of iodine in the system, as has been done with Fig. 6, Plate 1, which was acted upon in saliva from the same source as the preceding.

Fig 2

Fig 1

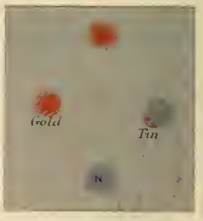


Fig 3

Blue litmus Paper moistened with boiled water and subjected to Electro voltaic decomposition

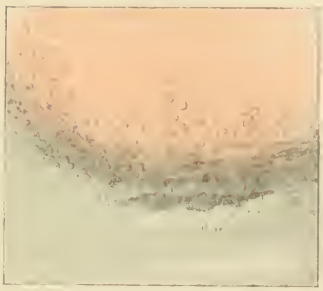
Fig 4

Ditto with water in which decayed teeth have been macerated

Fig 5

Ditto with saliva 15 minutes

Fig 7



Electro bone substance with lime globules shewing positive side acid & negative side alkaline

Fig 6

Ditto with salt 5 grs to the oz. 2 minutes

ing this question a most interesting and highly important fact has just been brought to light, which may assist very materially in determining the suitability of a metallic substance for the purpose. The idea suggested itself as to what might be the relative electrical condition of the several metallic stoppings now in use with regard to the electrical condition of the dentine, and it was found on experiment that while *gold* was *positive and in the same condition as the dentine*, *tin* was powerfully *negative*, and in this respect in the same relative state as the carbon, and consequently an unsuitable metal for a stopping. Nor is this all, for it was also found that with the *tin* plug a strongly marked *acidifying local action* was produced. A plug of tinfoil was made in a piece of dentine and placed under the influence of a current of electricity; a piece of litmus-paper was then moistened with salt and water, and placed upon the surface, with the positive pole resting at *p* and the negative pole at *n* (Fig. 7, Plate 1). The effect after a few minutes is represented in Fig. 2, Plate 2; it being impossible to preserve or dry the litmus-paper without the acid. A metallic plug of gold being in the same electrical condition as the crown of the tooth, is a perfectly *inactive* agent, beyond the mere effect of pressure and confinement of any fluid that may exude from the pulp; whereas, any other metal that may be *negative* to the *crown of the tooth* induces local action, whereof

the acidifying pole is opposed to the negative pole of the tooth, which is its fang; and hence this condition accounts for the decay so constantly occurring in lateral stoppings at or below the free edge of the gums (Fig. 1, Plate 2). A plug of gold was substituted for the tin, and the spot, instead of being blue, was merely reddened, without the slightest trace of local or induced action. In the tin we have a strongly-marked reaction developed in the spot *nearest to the negative pole*, which corresponds with a metallic stopping in the *side* of a tooth tending to become imperfect, most at the point nearest to the fang or negative part of the tooth, because it is here the polarity of the plug produces the polar condition which first leads to the generation of the acid. Other metals have been tried with the most decided results (Figs. 3, 4, 5 and 6, Plate 2); but the comparison of them is irrelevant to the present subject, besides requiring still further investigation: the *fact* alone has only been brought forward as another instance of the corroboration afforded by the phenomena of electricity for establishing the identity of the results occurring both in and out of the mouth as proceeding from the same physical source.

35. In pursuing the experiments in electro-decalcification, it was found that while it could be effected in water alone, there were other media by which it could be more rapidly and more exten-

sively produced. Thus a weak solution of sugar and water was found to be more active than water alone, but albumen from the egg and serum from the blood proved far more powerful agents, partly through forming better conductors by their viscidity, and also apparently from the decomposition of the chloride of sodium they contain, forming hydrochloric acid and chlorine; the saliva, too, is more active when thickened with mucus than in a less viscid state. Specimen Fig. 8, Plate 1, is an upper molar sawn through the centre of a decayed cavity. The part *b* is seen as left by the saw: the other part, *a*, shows its condition after twenty hours' decalcification in a weak solution of sugar and water. The pulp-cavity in the part *b* is perfectly free from decay within, and contains large masses of secondary dentine, while the part *a* has had the decay extended artificially, and in the absence of the negative pulp-vessels the cavity has also become enlarged. Specimen Fig. 9, Plate 1, has been treated in albumen thickened with a portion of the yolk, showing that the more viscid the medium within certain limits, the more diffused will be the decalcifying effects.

36. In all cases the decalcified dentine will be found to be strongly acid, and whenever a fluid containing albumen has been employed, there is invariably found an adhering portion of consolidated substance between the two poles, as at

a (Fig. 9, Plate 1); and hence we have an effect exactly similar to the production of the transparent zones which form around a decaying centre, and therefore have no need to seek for the cause of the latter in a *vital* action, when it is shown to be a natural consequence of the physical condition of the parts concerned.

37. The amount of substance produced in this part, however, is but small in comparison with what takes place in the pulp-cavity under more extensive excitement, the pulp itself being sometimes almost obliterated; but as these calcareous deposits can be so perfectly imitated by artificial means, there can be no doubt of their non-vital but physical source.

38. It will have been observed, that the pulp-cavity once reached is rarely opened out much by decay, but the carious cavity tends to enlargement *laterally* (*b* Fig. 8, A Fig. 10, A Fig. 11, Plate 1). Were the pulp in a positive state, like the dentine, and like the pole of the battery which rested at *p* (Fig. 8, Plate 1), its moisture and action would have tended to enlarge the pulp-cavity so as to throw this and the carious cavity into one; but its being electro-*negative*, the pulp-cavity is protected from being electro-voltaically acted upon; and we see this same condition further extended in the state of the dentinal fibrils, as continuations of the pulp. Mr. Tomes has informed us that the connecting material is

usually the first, and the walls of the tubes the last, to become disintegrated. So that while the negative pulp protects the cavity, the negative fibrils protect the walls of the tubes; and thus we have a consistent explanation of the whole proceeding. But when this action is going on, the tendency to new formation through the electro-voltaic action, leads to the consolidation of the fibrils in the early stage, and later, to an accumulation within the pulp, while the cavity itself mostly becomes added to on its inner surface, so as to lessen its dimensions—a tendency advantageously exerted when it leads to "calcification" of the exposed surface of the pulp. But the latter action is commonly attributed to the vital powers in the tooth. Unquestionably, if there were no vital powers in the tooth, it could *not* take place; but the vital part of the action is confined to the *circulation of the albuminous material in the arteries, veins, and capillaries of the pulp.* The connection of the latter with those of the cutis shows the pulp to belong to the cutis, which is the negative layer of the peripheral battery, and to be hence endowed with the same acting powers; but all the appearance of vitality possessed by the layers outward of the pulp is *due to their being electro-voltaically arranged and acted upon.* The tooth papilla growing from its infancy to its full size and shape in the dental follicle, is purely an act of vitality by cell-growth,

with a design and a purpose. But the embryo tooth thus produced is a *soft* material, requiring further elaboration; therefore a secondary action of a purely physical character is then induced, which leads to its becoming encased with enamel and dentine. The vitality of the pulp furnishes the material for these changes, but the electro-voltaic arrangement of the tissues converts them, by a kind of galvano-plastic process, into an organic form.

39. The circulation of the albuminous fluid out of which they are formed is due to the vitality of the vessels, and their connection with the general vitalization of the organism; but its being exuded when new substance is about to be formed, is owing to the electrical condition of the parts, by which it is not only abstracted when it is wanted, but is also disposed of under certain fixed and definite laws, in the special form required.

40. Having thus traced out the electrical organization of the peripheral battery of the system, which includes the dentine as a part of it, and having also shown the "progressive decomposition" of the enamel and dentine to be due to local electro-voltaic action, it remains to be seen under what circumstances the earlier stages of decay have their origin, and how far they may be likely to be affected by the secretions of the mouth or other adventitious circumstances.

41. It is one of the laws of nature, that, in organic matter in a moist state, stagnation leads to a change. In all living forms a special organization is provided for the fluids which are required in growth to be kept in constant motion. When this organized structure is either bruised, broken down, or otherwise injured, so as to prevent the capillary action by which the moisture is passed on, the injured part is thus shut off from the circulation, and, according as it may contain little or much moisture, in time becomes decomposed or rotten.

42. In the organization of the tooth, the soft fibrils extend to the enamel, and sometimes into it; and as we know the enamel to be capable of absorbing moisture after being suffered to dry, we have a right to infer that it, as well as the other coverings of the cutis, is capable of giving off moisture in the same way as may be traced in the insensible perspiration of the skin; and, in fact, we have no reason to doubt this when moisture may be collected readily from over the finger-nails, and therefore may take this as a clue to some of the more obscure conditions predisposing to the commencement of decay.

43. In mouths imbued with thick and glairy secretions of mucus, it is well known that the gums are generally less healthy, and the teeth more prone to decay and more rapid in their decaying, than where the saliva is less viscid.

That this should be the case would be inferred from the analogous effects upon the human system generally under corresponding conditions: when placed in an atmosphere so saturated with moisture that the insensible perspiration is unable to escape, sickness and disease are certain to result. In Fig. 12, Plate 1, we have a good illustration of the effects of stagnant moisture upon a denuded surface of dentine. On the lower face of the notch, which, from its having been on a level with and parallel to the line of the gums, would have been kept constantly immersed in the saliva, eremacausis and decay have taken place; while on the upper face, the surface inclined downwards and equally free from friction, still retains its polish, and is perfectly free from discoloration.*

44. The condition of dentine placed in the mouth *artificially*, corresponds fully with the preceding case: where friction keeps the part free from stagnant moisture, its homogeneity is pre-

* The immediate cause of the production of these notches, as well as the denuded portions of the facial surfaces and edges of the incisor teeth, has never yet been satisfactorily explained. In Figs. 13 and 14, a portion of a sound and healthy tooth has been electro-voltaically acted upon partially, so as to leave an indentation with the peculiar sharp edge which is a characteristic feature in these occurrences. It has also left a degree of polish very different to what is produced by the reaction of an acid in the ordinary way, thus showing a strong ground for attributing the natural occurrence to this same electro-voltaic action, as effected by the positive surface of epithelium of the lips in contact with them, it being the conduct of a positive pole to transfer the alkaline matter to the negative layer.

served; but where moisture is allowed to become stagnant, a change soon occurs; the part thus soddened with moisture becomes a prey to the local action of the saliva, which has been shown to be a powerful *electrolytic* destroyer of dentine.* It is well known that where an artificial denture of ivory is acted upon by friction in the mouth, its polish is preserved, although other parts become decayed; but these polished portions after a time mostly become dark and discoloured; the retention of the polish is most confirmatory evidence of the entire absence of all acid reaction upon the part from any acidity of the saliva, and proves the change most indisputably to be a prior occurrence to the production of the acid, and "from the fact that, points of action having once been established, the corrosion is increased by the effects itself produces" (sect. 30). The negative points thus established soon set up sufficient local action to decompose both the dentine and the saliva, leaving the softened tissue—the decalcified membranous matrix of the dentine—to extend its action by its own effects. That it is capable of doing this, and that the negative condition of the element first giving rise to decay is continued in the same state as the decay proceeds, is proved by

* B, Fig. 11, Plate I., is one part of a divided molar, showing forty-eight hours' decalcification in saliva. The positive pole was made to rest on the edge of the original decay, so as to produce its extension; and to what extent this has been effected will be seen by comparing the two portions, A and B.

the following experiment. A molar tooth, which had lost about one half its crown by decay, was sawn through the middle, as near as possible, into two equal parts. One of these (A, Fig. 10, Plate 1) remains as cut; the other (B, Fig. 10, Plate 1) has been twenty-four hours under action in saliva. The positive pole was placed at *p*, the negative at *n*. Had the crown of the tooth been in a homogeneous state, the decalcification would have extended across the upper or positive half of the tooth, as it has done in Figs. 9 and 15, Plate 1; but instead of this, the *surface of the cavity has become lined with concretions of lime removed from the decalcified dentine by the side of it.* This is a conclusive proof that the surface upon which the lime rests is electro-*negative*. Were it otherwise, it could not have been so deposited; its electro-negative condition has preserved it, in the same manner as did the tartar in Fig. 5, Plate 1. We have also in the specimen B (Fig. 10, Plate 1) a very intelligible explanation of the accumulation of tartar upon the *necks* of the teeth. The crown of the tooth being analogous to the outer layers of the skin, is consequently electro-*positive*, a fact which is proved by the occurrence of acid within its substance; but the fang of the tooth, from its connection with the cutis, through the vessels of the periosteum, is electro-*negative;* and hence, when any decomposition may be going on which produces a supply of the alkaline matter, it is attracted to

the exposed portion of the negative under the free edge of the gum as a natural consequence of its condition.* In Fig. 11, Plate 1, the positive pole was placed *on the edge of the pulp-cavity;* consequently the power of the battery overcame the more feeble power of the carbon and set up positive action in the two cavities, the pulp-cavity and the carious cavity; but in Fig. 10, Plate 1, the pole resting in the centre of the sound dentine was sufficiently distant to be unable to overcome the negative tendency of the carious cavity; and hence the latter became the recipient of the lime, as the most intensified negative part of the action.† Thus it is by the surface of a carious spot retaining its electro-negative state and increasing its area, that it becomes the extender of the mischief itself produces.

45. It will have been seen that electro-chemical decomposition depends very greatly for its amount and rapidity of action upon the condition of the

* The author has always felt assured of the accumulation of tartar upon the necks of the teeth being due to something more than simple deposit of an ordinary precipitate from the saliva; because the mere lodgement alone would not in preference take place around the necks of the teeth and upon upright surfaces, and attain its great degree of hardness, without some attractive force compelling its cohering and its attachment.

† In the same manner that the fang of the tooth sometimes has its electrical state reversed from the negative to the positive, so the enamel, when active decay is taking place, often becomes negative and receives a coating of tartar up to the very edge of the cavity; a state which protects the enamel from being acted upon, and causes it to become undermined, as in the specimen Fig. 1, Plate 1. .

electrolyte or fluid element of the series; and as the state of the fluids in the system is known to vary very much in health as well as in disease, and to be considerably affected by various medicaments taken internally, this difference at different times is abundantly sufficient to account for the tendency to decay at one time more than another without any very apparent cause.

46. It has been shown that the arrangement of the several layers of the skin, and the several layers of the tooth—the enamel and dentine (as one) and the pulp are in opposite electrical states, and correspond in disposition and effects with a galvanic series, and that the formation of dentine as a physical result derived from its action is amply borne out by experiment; hence there can be little question as to other consequences arising from the same arrangement, "for no voltaic battery has as yet been constructed in which the chemical action is only that of combination;" "*decomposition is always included*, and is, I believe," says Professor Faraday, "an essential chemical part" (858); and thus we may very justly attribute the decomposing effects in decay to the same cause.

47. In endeavouring to illustrate this subject with a series of results which as near as possible should correspond with the natural occurrences in the mouth, a number of new and highly interesting facts have been pointed out; and, as Sir Humphry

Davy remarks, "Concerning the publication of novel facts there can be but one judgment, for facts are independent of fashion, taste, and caprice, and are subject to no code of criticism; they are more useful, perhaps, even when they contradict than when they support received doctrines, for our theories are only imperfect approximations to the real knowledge of things; and in physical research, doubt is usually of excellent effect, for it is a principal motive for new labours, and leads continually to the development of truth."

APPENDICES.

APPENDIX A.—NON-VITALITY OF DENTINE.

In what does vitality consist? If we take an egg, a nut, or a seed, and place it under the particular circumstances required for enabling its powers of vitality to become manifest, we obtain by such means a special result, in the growth and development of a living organism. But if we break up the egg, split open the nut, or crush the seed, although every atom of their respective contents may be present, their power of growth will have ceased to exist. They will have lost their vitality.

If we take a pip from an orange, a lemon, or an apple, each one contains within itself that which enables it to grow. It is the seat of life. It possesses "vitality." But if we take cells from the pulp, or a slice from the rind, although each one is equally a product of vitality, we shall obtain *no* development of a plant by their growth, simply because they were never intended to grow, and hence were never endowed with "vitality."

We may take a cutting, a bud, or in some cases a leaf, or even part of a leaf, from a plant, and each one can be made to develop itself into a living and growing individual, identical with its parent form; but split off the bark from the cutting, break asunder the bud, or tear open the leaf, and the power to grow ceases with the separation of the parts. All that has been destroyed has been the arrangement of the substance which constituted its condition of vitality.

If we take for a cutting a portion of the stem of a

rose, it is indispensable that it should contain a bud or "eye," because the bud or eye alone possesses the condition of vitality essential to its growth, the stem being only an accessory and unessential part of the arrangement for growing; it therefore is not endowed with vitality. The same may be said of the skin. In all rhino-plastic operations, it is necessary to include with the transplanted flap a portion of the cutis, because the vessels of this part alone contain the essentials of growth. There is, however, one other condition necessary to success; which is, that the vessels of the transplanted portion must remain, or be placed in connection with the circulating fluids of the system. Their vitality is not inherent in the vessels themselves, but depends upon their forming a portion of the general vitalization of the organs; and hence the circulation of the blood within them is one of the conditions constituting their vitality. What we are to understand by "vitality," then, is the being possessed *of that special arrangement of parts, which, out of unorganized matter elaborated in the system, leads to the development of organized forms and the powers and functions of life.*

In this respect the cuticle and basement membrane, *independently of the vessels of the cutis,* have no power of organizing fresh material; while stripped of their coverings, the cutis, or true skin, is enabled to repair the deficiency by organizing for itself a new formation in the place of the part removed. Here, then, we have the cuticle evidently subordinate to and resulting from the vitalized arrangement of the capillaries of the cutis; and as the vitalized organization of the system has need of non-vitalized adjuncts to enable it to carry out the special duty of the different functions of the vital organism, it thus provides the bones, muscles, tendons, ligaments, membranes, &c., which serve for its aid and protection.

We thus have in the living being two distinct conditions of matter; the one vitalized and essential to the life of the part, the other non-vitalized and subordinate or accessory to the former. These, however, both depend for their continuance in existence on progression or constant motion of the fluids they contain; otherwise stagnation in contact with the air leads to a change which develops one or more of the physical forces by the decomposition or decay it produces.

In addition to the continual passage of moisture through the substance of organic products in connection with the living organism, most of these bodies are perpetually undergoing a renovation or replacement by new, as the old portions are either taken up again or discarded from the system. Among the principal exceptions to the latter rule are the enamel and the dentine; the former being *never* replaced, and the latter but partially so, and then only by an unorganized and almost structureless mass.

Albumen, which enters largely into all organic forms, is composed of elements put together in such a manner as never has been effected by the hand of man. It is therefore termed "vital," and being a vital substance, the force which holds it together is designated the vital force. It has been supposed that this vital force, which has been instrumental in the production of all organic forms, is capable of migrating out of one form into another; that vital force is given out in decaying wood, and becomes the life of the fungus which grows upon it. Professor Grove has shown us that all the physical forces "are correlative, or have a reciprocal dependence;" each one producing *other* forms, but "*merging itself*, as the force it produces becomes developed." Therefore in the decaying wood we have other forces, as heat, light, chemical affinity, &c., appearing in lieu

of it; "it being an irresistible inference, that a force cannot originate otherwise than by generation from some antecedent force or forces;" and heat and light, in combination with moisture, are known to be the most powerful abettors of life and growth. Organic matter exerts no influence upon other forms of growth, until the *chemical* force begins to set free the elements formerly held together by the *vital* force; and as all cryptogamic as well as other vegetation is known to arise from spores or seeds, and these spores containing within themselves the germ or condition of growth, are teeming in every direction, wanting only the presence of moisture to start them into growth, together with a suitable nidus, which is here found in the decaying organic matter. The fact of seeds germinating in pure sand and water proves them not to be dependent on receiving vital force from other sources. Are we not, therefore, justified in regarding dentine as a vital body, but not possessed of vitality?—as a substance composed of elements united by the force which is understood as the vital, but acquiring its physical condition of form and density through a physical force originating from the vitalization of the pulp and its vessels.

APPENDIX B.—PHYSICAL NATURE OF DENTINE, AND ELECTRO-FORMATION OF BONE SUBSTANCE.

The persevering efforts that have been made to endeavour to interpret the formation of dentine by the cell-development theory, and the persisting in this course to the exclusion of seeking in other directions, has led to this being less understood than almost any other substance to be found in the animal system.

That cell-growth is concerned in the formation of the tooth is unquestionably true, but its action is limited to the *production of the mould and its matrix or core, upon which the dentine is deposited.* The manner in which dentine commences and continues to form renders it necessary that some means should be provided by nature that the outer layer, which is the first to form, should be of the exact size and form of the future dentinal crown of the tooth. This is accomplished by the tooth papilla attaining, by cell-growth, a soft, pulpy mass of the dimensions required. But with the attainment of this, the *vital* part of the process to a certain extent terminates ; the *vital* force, no longer required for assimilating growth, merges into the electrical, and hence, by the action of a *physical* force, completes the transformation, or rather replacement, of the soft by its hard and stony successor. The pulp in its soft state is still covered with basement membrane and epithelium, but as the formation of these substances is no longer required to be continued, the albuminous material which went to form them now begins to accumulate at the centres of ossification to form the basis of future dentine.

Soon after this has commenced, it becomes tenanted by minute granular bodies, which, continuing to increase in size and quantity, ultimately assume the compact and

dense form of a bony deposit. The granular bodies constituting the hardening element of bone, at one time were looked upon as "solidified cell-contents;" but the true character of these formations has been fully demonstrated by Mr. George Rainey* as being nothing more than a peculiar form of crystallization of the salts of lime, due to the viscidity of the medium in which they are formed.

These "artificial calculi," as they have been styled by their discoverer, were obtained in great abundance from a viscid solution of gum acacia, but they were entirely isolated specimens in their most perfect form.

By means of electricity the Author has succeeded not only in producing them in a very much shorter period of time, but also in obtaining a membranous matrix out of albumen, having within it these deposits in a definite layer, coalescing and aggregating together, and closely approaching the appearance presented at the edge of a natural bone in its early stage of formation.

In electro-voltaic decalcification of bone, the salts of lime pass *from the positive to the negative pole*.

Under the action of electricity, albumen is coagulated and rendered insoluble;† but there is more than this,—it assumes a definite shape and structure, very much after the manner of iron filings between the two poles of a magnet.

Around the negative pole is formed a cell-like sphere of highly transparent and glassy-looking substance (Fig. 16), while at the positive pole the mass collected is granular and somewhat opaque; but intermediate, a wall of substance forms and spreads out right and left so as to separate the contents of the vessel into two distinct portions.

* "On the Mode of Formation," &c. G. Rainey, M.R.C.S.

† Brande's "Manual of Chemistry."

According to the law enunciated by Mr. Rainey, it was easy to foresee, that if viscidity were the true cause of

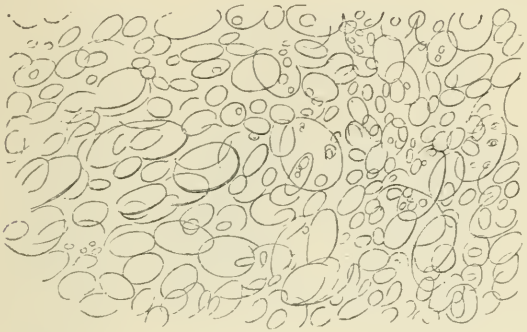


Fig. 16.

the salts of lime taking the globular character instead of the usual form, by electro-decalcifying bone in a viscid solution, the salts of lime would be arrested in their passage from one pole to the other, and take up their position within the coagulated albumen as a matrix. This they have been found to do, not indiscriminately, however, but aggregating together in a layer in the interior of the substance, forming the septum or diaphragm c across the vessel between the two halves of its contents.

Fig. 17.

Fig. 17 represents a vertical section in the line of the two poles, or at right angles to the diaphragm, showing also a free border of unappropriated matrix on either side

Fig. 18 is a square vessel, actual size, in which the experiment was made. Fig. 19 is a vertical section of Fig. 18 from D to D.

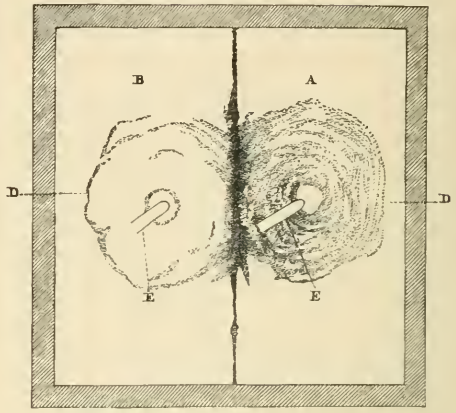


FIG. 18.

G, Fig. 19, is a piece of walrus ivory placed at the bottom of the vessel to furnish the lime transferred to the matrix C.

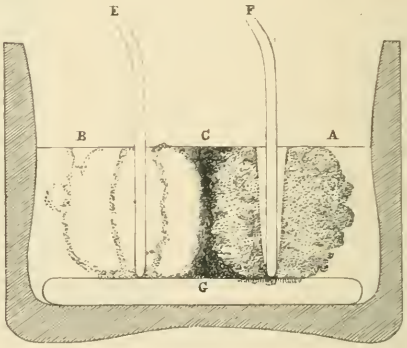


FIG. 19.

E is the negative wire and F the positive. The shaded portion of G shows the extent to which decalcification proceeded. Fig. 17 is a minute portion of C, in the

line DD. In mounting, it has been pressed out, so that the line of lime has become crushed down and spread out. Fig. 20 is a small portion further enlarged. The scale below each represents the hundredth of an inch; Figs. 17 and 20 having been traced with the camera.

Fig. 20 is a more highly magnified portion of the edge of the lime, showing the globules coalescing into a more solid form.

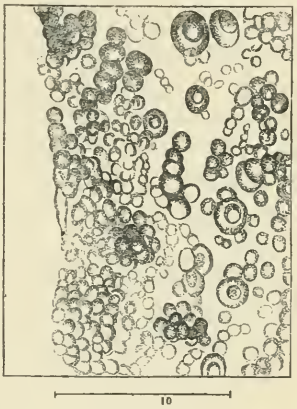


Fig. 20.

Fig. 7, Plate 2, shows a portion of the same, but with a piece of litmus test-paper applied to it while soft, showing the acid and alkaline condition of the opposite sides of the structure, with this complete similarity of proceeding and corresponding nature of the results between the artificial production of what may be termed bone-substance, and the natural process in the development of the tooth; and as this occupies in nature the same relative position in the peripheral battery of the system that it is found to do when produced artificially, there can be no hesitation in accepting them as being both produced by the same physical force. The peculiar structures which have hitherto caused so much perplexity as supposed "formative membranes," are here shown to consist of nothing more than a *free and unconsolidated border of the membranous matrix.* The cause of their separating readily as apparent membranes under the action of an acid or in suppuration, may be ascribed to a similar effect of the line of consolidated globules, as the line of perforations produces in a sheet of postage stamps. There are various other minutiæ traceable in

the development of the natural organ, which may be equally illustrated by the same means; but sufficient has been said to afford an ample demonstration of the fact, that the production of dentine is due to a physical force developed and fed by the vitality of the vessels in its pulp. What I have here sought to establish is, that *certain parts* only of the living organism are endowed with "vitality," or with that condition and arrangement of parts necessary to the accumulation and organism of organic material into organic forms; and that as these organic bodies are then of themselves not required for, nor capable of organizing, other material, they are not endowed with vitality, but possess only physical properties essential only for maintaining the persistence of the organic fabric. That these organic forms contain a force keeping them in combination, which we designate *vital* because it is not producible in any other way than as the result of life and growth; and that as all the physical forces require some antecedent force, no force being able to originate itself, we have the vital force as the starting-point or great storehouse from which the physical forces emanate. And that as we have this vital force in the system correlated into motion in some cases, into heat and into chemical action in others, we have it also correlated as well into electricity, which has been shown to contribute certain definite characters and organic material corresponding in many points with natural products; and hence it has been assumed with a very fair show of reason, that as the *other* physical forces are absolutely necessary to the *production* of animal forms, electricity should also be employed.

APPENDIX C.—STRUCTURE OF THE ENAMEL.

The structure of the enamel has been described by all physiological writers as of a *crystalline* character, with the crystals prismatic and placed endwise to the pulp, and as being formed through the instrumentality of what has been termed "the enamel organ;" but beyond this, no further advance appears to have been made in tracing out the laws of its formation. Now, it can be shown that the entire coating of enamel upon a human tooth is arranged as a portion of one of the globular crystals of lime, such as are formed in developing dentine.

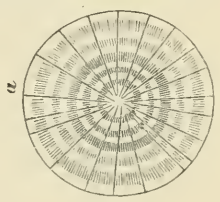


Fig. 21.

Fig. 21 is from one of the artificial calculi given by Mr. Rainey at page 12, Fig. 4 *a*.

Fig. 22 shows a circle filled up in the same manner with lines radiating from the centre to the circumference, and corresponding in this respect with the Fig. 21. The thin line drawn across will show an apparent section with the supposed enamel fibres, as seen in nature. If a pin be passed through the centre of the radiating lines, the tracing might be turned in any direction, while the radiating lines will retain their relative position, showing the centre of the enamel lines to fall somewhere near to the centre of the crown of the tooth. In a multicuspid tooth a very slight variation will be found in the action, being a tendency to produce several different centres, and give rise to a somewhat compound crystal, with as many short lines instead of a single point for its centre. To obtain this coating of enamel is one of the main objects of the tooth papilla sinking down into the capsule within the jaw-bone. When the dentinal papilla has grown to its full size, the capsule

surrounding it forms a casing with the epithelium of the two surfaces in contact; therefore the inside of the

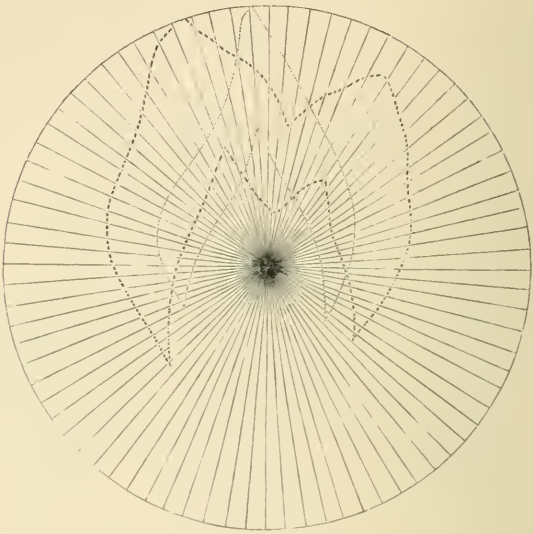


Fig. 22.

capsule must correspond in shape with the outside form of the papilla; and hence, when the capsule is distended by the plastic mass of the forthcoming enamel, we have a mould which in some measure determines the shape and thickness of the future layer.

The fluid or plasma of which the enamel is formed, "resembles in consistence the albumen of a common fowl's egg, and like it will run off an inclined surface. It has a sticky feel to the fingers, like a strong solution of gelatine."* We have thus the viscid medium required for giving rise to the globular form of the crystals, while the reason that one large crystal forms instead of a number of small ones, is evidently due to the attractive force of the one or more negative centres of the pulp

* Tomes's Lectures.

overcoming the tendency of any weaker centres within the plastic mass itself; and being moulded to the interior of the capsule, is thus prevented assuming its own exterior globular shape, but is made to take that of its mould.

APPENDIX D.—ABNORMAL ENAMEL.

"The direction taken by the enamel fibre is, for the most part, vertical to the surface of the dentine upon which it rests; those, therefore, which proceed from the flat surface of the crown will rise vertically, while those from the lateral surface of the tooth will be horizontal. . . . . The ends of the enamel fibres are received into the shallow hexagonal depressions of the coronal surface of the dentine, from whence, in their course, they describe frequent curves." Such is the description given by Mr. Tomes in his Lectures, page 52: of which the former portion relates to its *normal* state, while the latter refers to an abnormal condition produced by a disturbing cause during the period of its formation. The dentine, beginning to appear on the pulps, spreads over the surface of the latter, forming a thin shell down to the junction with the lower edge of the capsule. On its outer surface rests the basement membrane, upon which the enamel crystals are arranged. Fig. 9, Plate 1, has a portion of the transverse septum left attached, to show its positive or outer surface covered over with pit-like indentations, and this surface corresponds with the positive or outer surface of the dentine. When this shell of dentine has formed upon the pulp, prior to any of the plastic mass of the enamel having become fully crystallized and adherent, the radial lines of the enamel will be straight, or normal, as in Fig. 23; but when the *crystallization has commenced before* the dentinal centres of ossification are complete, or

the pulp fully matured, the cusps of dentine, as they become perfected, rise up into the semiplastic mass of crystallizing enamel and force or drag the adherent crystals with them in their upward course. This action will be clearly seen to have taken place, by the accompanying sketch, Fig. 24; the two cusps having produced their disturbing effect most upon the apex, but less and less downward towards the neck of the tooth.

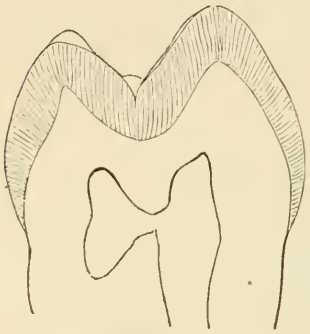


Fig. 23.

If on the completion of the dentinal crown and its commencing to rise by the growth of its fang, the whole of the enamel be sufficiently "set" to be elevated with it entire, the outer portion of the enamel attains a normal direction; otherwise a fresh set of curves will be produced on this part, rendering it also abnormal.

Fig. 24.

It is but reasonable to conclude that any such interference with the half-set crystallization must tend to weaken its attachment to the surface of the dentine, and render the enamel less homogeneous; and not only is there thus a tendency for the cohesion among its own particles to be lessened, but a curved line in the place of a straight one presents a physical defect, which, on the ordinary principles of mechanics, must offer a weaker resistance to outward pressure than the straight one; and hence, this description of enamel will necessarily be weaker in resisting the

effects of lateral pressure than the normal arrangement. The examination of a large number of teeth showing incipient decay has led to the conclusion that the condition of the enamel in this respect materially influences the results of the crushing effects of lateral pressure, and that the more vitreous and dense, that is, the more perfect and normal, the crystallization of the enamel, the less does it appear to be the subject of injury.

SUMMARY

OF THE PRECEDING FACTS AND CONCLUSIONS.

1. That dentine can have no claim to be considered as possessing "vitality," but that it is simply a vital product in an organic form.

2. That the vessels of the pulp—namely, the nerve, artery, veins and their capillaries, together with the vessels from the periosteum, are the only parts of the tooth endowed with "vitality."

3. That the pulp-vessels, together with the dentine and its enamel, in conjunction with the albuminous fluid with which they are moistened, *form an electro-voltaic series*, and are a portion of the peripheral battery of this system.

4. That the result of such an electro-voltaic arrangement is to withdraw albuminous material from the blood circulating in the vessels of the pulp, and to effect its consolidation according to certain fixed laws.

5. That the formation of dentine is due to this electro-voltaic action. The growth of the dental papilla to the size and form of the future tooth being purely an act of vitality, the subsequent deposit of membranous matrix, together with its becoming filled up with the salts of lime, are clearly demonstrated, *by the artificial production of bone-substance*, to be due to a physical or electro-voltaic action.

6. That any seemingness of vitality in the dentine may be ascribed to its being imbued with albuminous fluid, and constituting the positive elements of a galvanic series, of which the negative is supplied by the negative vessels of the vital pulp.

7. That local action in an electro-positive element constitutes the decalcifying and acidifying process in decay.

8. That as some forms of carbon are among the most powerful electro-negative bodies in nature, this local action is first started by an electro-negative point of carbon, or by some want of homogeneity in the enamel or dentine.

9. That it occurs in pits, fissures or porous parts of the enamel through a deposit of carbon, or by eremacausis of the membranous matrix, the organic portion of the enamel and dentine.

10. That a minute portion of carbon forms an electro-negative centre, has been shown by the carbon placed in the notch of specimen No. 5, Plate 1, having protected that side of the tooth from electro-positive action.

11. That the supposed death of the dentine is simply a well-known description of decomposition, common to all organic matter, and known as eremacausis, or slow combustion.

12. That the carbonaceous substance resulting from dry decay is at first alkaline or neutral.

13. That it is only when it has become saturated with stagnant moisture that electrolytic action commences and acid is formed.

14. That plain water is capable of producing an electrolytic decomposition of the dentine, and leaving acidity in the decalcified tissue, but that fluids containing inorganic salts produce more extensive action.

15. That sugar and water produce a more decided effect than plain water, but that saliva is by far the most effective agent.

16. That the various acids to be found in the mouth are derived from the separation of acids from their bases, together with the oxygen, obtained from decomposition of the water forming the electrolyte, combining with

different organic bodies, or their elements, contained in the saliva as it comes from the ducts.

17. That substances taken internally are to be traced in the saliva, is shown by the voltaic detection of iodine after taking small doses of iodide of potassium.

18. That in respect to the progressive decomposition of decay, the enamel is sometimes found corroded in holes before any signs of decay have become apparent in the dentine (*a*, Fig. 2, Plate 1), showing the organic matter mixed up with the enamel to be affected similarly with the matrix of the dentine.

19. That the transparent zones of Tomes, or consolidation of the dentinal fibrils, is frequently the first change that takes place in the dentine. (Fig. 4, and *a* and *b*, Fig. 2, Plate 1.)

20. That when albuminous fluids are acted upon electro-voltaically, the albumen becomes consolidated in a definite form—granular and somewhat fibrous at the positive pole, highly transparent and jelly-like at the negative, and *with a densely-formed wall of substance transversely between them.*

21. That when dentine is electro-voltaically decalcified in albumen, the consolidated portion between the two poles receives a deposit of globular concretions of lime, almost identical in appearance with similar concretions seen in the edge of newly-formed dentine.

22. That in all deposits formed in albuminous matter by electricity, a *free border of transparent matrix remains unappropriated,* which corresponds with the transparent rings and periosteal layer of bones and the so-called formative membranes in the teeth.

23. That the zones of secondary dentine, as also the portions of granular concretions, adherent to the cavity or scattered in masses within the substance of the pulp, are due to the electro-voltaic deposit induced by local electro-voltaic action, and that consequently

calcification of the pulp is to be induced by the same means.

24. That in the consolidation of albumen electro-voltaically, the *negative* side is always *alkaline*, while that formed at the *positive side is invariably acid.*

25. That in this respect it corresponds with the layers of the skin, where the blood-vessels, in health, are alkaline, while the epidermis and epithelium are acid.

26. That it is this condition which produces the acidity in the mucous surface of the gums.

27. That in every instance in which acidity can be traced in decaying dentine, the vessels of the pulp will invariably be found to be alkaline or neutral; thus indicating their different electro-voltaic condition.

28. That the lateral spreading of a carious cavity, and its not more extensively opening out the pulp-cavity, is due to the electro-negative or opposite condition of the pulp serving as a barrier for its protection.

29. That the dentinal fibrils exert the same negative tendency in protecting the walls of the dentinal tubes, causing "the intertubular substance to be first, and the walls of the tubes the last, to disappear;" and hence the improbability of effecting the same condition artificially.

30. That the decalcified surface of a carious cavity continues in a negative state as the decay proceeds, and thus keeps up the local action as it extends its area. (Fig. 10, Plate 1.)

31. That it is only after having lost the protecting influence of the healthy pulp that the cavity has its negative condition overcome by the positive and merges into the decaying surface.

32. That decay may be produced and carried on artificially by electricity, although the decalcified tissue requires the effect of time to accomplish its discoloration.

33. That the notches at the necks of the anterior

teeth greatly resemble the effect of local electro-voltaic decalcification of healthy dentine, as produced by these means in Figs. 13 and 14, Plate 1.

34. That as too viscid a state of the albumen used in the electro-voltaic experiments was found materially to prejudice the condition of the deposit of lime, so the state of the albuminous fluid of the system going to form the dentine may be supposed to exert a similar influence on the texture and hardness of the tooth as well as on its predisposition to decay, and thus account for the difference in this respect occurring in different mouths.

35. That as the structure of the enamel shows it to be a portion of one of the globular crystals of lime formed in a viscid material, the so-called enamel fibres are but the characteristic features of the radiating form of its aggregated atoms.

36. That as the radiating lines in the enamel in their normal form are straight, the curves formed at the cusps are abnormal and due to a disturbing cause during the growth of the tooth, which, by disarranging the accumulating crystals of enamel before attaining their full consistence, may lessen their cohesion and thus predispose the parts to decay.

37. That the dentine forming the crown of the tooth being produced in lieu of, and occupying the place of, the cuticular layer of the skin, is consequently in a corresponding electro-*positive* state; but that the fang being encased among the negative vessels of the cutis is normally electro-negative, and hence, like the surface of the cavity in B, Fig. 10, Plate 1, its negative condition induces the formation of tartar, which settles upon it; and also in decay prevents the cavity spreading down between the pulp and the periosteum much below the attachment of the latter; but when denuded of its covering, and its connection cut off from the vessels, the

exposed portion merges into the electro-positive condition of the crown, and thus becomes the victim of decay.

38. The influence of electricity is so palpably manifested in the generation of the tooth-coverings—substances which are not liable to the same changes of absorption and reproduction as occur in the vital parts, and as the effect of every voltaic series is not that of combination alone, but includes *decomposing* powers as a part of its constitution, we can scarcely refuse to accept the decomposition of the tooth-substance as arising from one or more contingent circumstances connected with the same arrangement which has constituted the combining force in its production; and more especially as the effects arising in the mouth correspond so closely with the results obtained artificially by the same means.

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